Young childrens collaborative problem solving in design and technology.

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YOUNG CHILDREN'S COLLABORATIVE PROBLEM SOLVING STRATEGIES IN DESIGN AND TECHNOLOGY

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Abstract

This study set out to identify and classify problem solving strategies of groups of young pupils working in design and technology (D&T) lessons. The study was longitudinal, following these groups from the age of five to seven years. Once a taxonomy of problem solving strategies was established, key research questions focused on the function and development of these strategies. The work took as its framework a constructivist approach but also drew on ideas from collaborative and situated learning.

A qualitative methodology was used. Observation of two samples of pupils, each comprising three groups of six children, was carried out twice yearly in the natural setting of their timetabled D&T lessons. The first sample was replicated by a second of the same age, size and cultural mix. The two primary schools were in a middle income area of a commuter town, similar in both social and physical context, with an upper working class, multi-ethnic intake. The groups in both schools worked on similar tasks each year using resistant, soft and malleable materials and associated tools.

Data analysis focused first on the creation of a general taxonomy, which was further refined iteratively through analysis of the role of tools and materials, and then on the nature of strategy development. The findings showed the strategies falling into two groups: subject specific and personal and interpersonal. The tools and materials helped determine the subject specific strategies, such as planning and practice, but personal and interpersonal strategies, such as sharing and cooperating, were more general. Subject specific strategies were context bound and developed by accumulation of knowledge and skills, while personal and interpersonal strategies changed qualitatively with age. Given the difference in nature, function and development of these groups of strategies, implications have been drawn for their enhancement during classroom practice.

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The Challenge of Design and Technology

Introduction

Primary Design and Technology (D&T) is a challenging and relatively new subject area without a tradition or clear definition, and is generally acknowledged to be still finding its place in the primary school curriculum. Although teachers work hard to make sense of the National Curriculum documents, they are demanding and difficult to interpret. The body of knowledge to which teachers and pupils should relate is not shared in a way that might develop skills, knowledge and technological understanding (McCormick and Murphy,1994). The Open University PSTE Project (1995) confirms that technology tasks make greater demands than is often realised on children's conceptual and procedural knowledge. At Key Stage 1 questions have been raised concerning whether this work is appropriate for young children and how they will cope (DES,1994). OFSTED (1997) claims that Infant teachers need guidance as to what they should be teaching based on a clear conception of what young children can do. Yet little is known about the problem solving strategies young children bring to design and technology tasks and how these might be expected to develop in the classroom. The opening chapter of the study explains the nature and values of D&T that make it unique, and its challenge for pupils and teachers at Key Stage 1. It makes a case for including the subject in the early primary curriculum, and for greater professional awareness of young children's problem solving strategies in design and technology.

1.1 What is Design and Technology?

As we reflect upon the millennium, and are constantly reminded of the technological changes around us, we may be tempted to feel that we are the first to live in a technological society. However, if we remember the rapid changes of the agricultural and industrial revolutions of the eighteenth century, and the expansion of trade and commerce, and subsequent technological growth following the discovery of the new world in the seventeenth, it seems that every age can be described as technological.

In his recent book on historical technology Landes (1998) traces the economic importance of invention through classical and modern times. He holds the view that the ruling class has throughout history held the power of technology in their grasp. This is an acclaimed work, but in many ways his stance is similar to the widely held position that views technology as a force which manipulates and controls human destiny and masters development. Here we are powerless in the clutches of a monster of our own creation. There is a constant flow of modern academic and popular literature that warns of the need for caution as technology demands more, not less, work from us in order to function, and is in danger of controlling us rather than providing a means for control (Feenberg,1991;Tenner,1996). Counter to this is the perspective of Latour

(1993,1995), Miller (1995), and Slater (1995) who explore technology through the relatively new area of Material Culture. They acknowledge the role of mass consumption and its values, ideology and mythology in the formulation and production of technology. They see us as active not passive in the creation and transmission of technology.

The notion that technology is socially constructed complements early theories of design and technology education. In a formative early work on technology education Black and Harrison (1985) described technology as the practical method that enables us to distinguish ourselves from animals and to create not only our habitat, our food supply, travel and communication, but art, music and literature. Later technology was described by Archer (1992) as one of man's fundamental activities, a unique process that defines creatures as being human; and recently in his address to the Design and Technology Association Annual Conference (1996), Mackenzie called it 'the means of life-long learning'. Technology then is a word used to describe both the technological *products* created by men and women, and the design and technology *process* that they engage in through this creation.

Two definitive attributes of human beings are: firstly, our ability to make and use tools in order to adapt our environment to our needs, and secondly our ability to invent and use language to communicate and work together. Through our use of tools we are able to discover and use the resources of the world, both natural and man-made; through our language we can communicate wants and needs, discuss possibilities and criteria, make choices and decisions, and form and express personal, cultural and aesthetic values. The design and technology process involves using imagination and enterprise to bring about material and social change. It is an intrinsic and important part of all cultures.

Learning through design and technology entails using strategies to cope creatively with complex problems in the everyday world. These strategies take account of a wide range of often conflicting demands and constraints, and involve solving real technical, economic, aesthetic, political and environmental problems. They also involve using personal qualities such as determination, intuition and perception. Black and Harrison (1990) feel that technological activity calls for sensitivity to alternative solutions, possible consequences, and to the values being pursued. Design and technology is a problem solving process that is at once reflective and speculative.

Problem solving strategies, however, require above all knowledge, skills and understanding of the task in hand. As Tickle (1996) says, design and technology requires intellectual and physical capability to move together. These skills and knowledge are drawn from a variety of disciplines or domains of human activity, such as mathematics, history, science, art, craft or business management. Moreover, learning through design and technology generates fresh knowledge and ideas, and may occasion the need for new skills, or prompt greater understanding or careful thought about associated ideals and values. Design and technology activity then both induces and draws upon a range of human experience.

Young (1995) has written that it is the context of the task and the resources available that dictate which combination of these areas of experience are used in solving

specific technology problems. Johnsey (1995a) also maintains that an awareness of the context or situation within which a need or problem has occurred is vital when tackling any task, as this helps us make informed judgments about the design to be used and aids us in making balanced evaluations.

Learning through design and technology involves devising strategies which use knowledge, skills, values and a thorough understanding of the situation, to solve everyday problems. This activity must be invaluable to any learner, especially as it generates further knowledge and skills, and a useful end product. This is one reason why it is desirable to begin to teach design and technology to young children at an early age, but it may be useful to look separately at the component parts of the subject in order to find further reasons.

1.2 The Relationship Between Design and Technology

So what is design, how does it relate to technology, and why teach it as an activity in primary schools? Perhaps a third great attribute of humans, together with tool-making and the use of language, is the capacity to imagine: to envisage a possibility or new reality, analyse it and model it externally. Modelling is the ability to image in the mind's eye (DES,1989), to conceive a construction or arrangement for a purpose, and to understand the need for order and pattern in complex systems. Modelling is to create a conceptual plan or sequence, analyse it and re-create it externally in order to test out its viability.

Sparkes (1993) has identified three types of 'modelling' in design. The first type of modelling, pictures, drawings or diagrams, is widely used, not only initially when we design, but in order to communicate ideas and give instructions for undertaking the work through all the stages of its realisation. Diagrams or sketches are often modified or changed in response to difficulties or new ideas as the work proceeds. Case studies in industrial design (Hinrichs,1992) describe 'trade-offs' or creatively relaxing the constraints of the original plans in order to move the work forward. The power of problem solving in design lies in human flexibility. Plans may use the signs or symbols that have become the common language of those working within the 'design culture'.

Secondly, and an extension of this use of symbols, is mathematical modelling. This is becoming more important as computers play an ever increasing role in technological design. Graphic computer design is used now in many primary schools, including programs for very young children.

Sparke's third type of modelling refers to physical models. Physical models are miniature constructions of particular aspects of an artefact or system so that it can be evaluated before producing the real thing. Model cars or boats for test runs, or model buildings for judging their appearance, or planning interiors, come into this category. Small scale models or 'prototypes' do not necessarily behave in the same way as large objects, and this type of modelling brings its own difficulties in terms of judging fitness for purpose. It also presents problems in teaching, as young children in particular may not view their models as transient but as ends in themselves.

Outterside (1994) has studied young children's representations, and has

remarked simply that 'modelling is the ability that we have to make one thing stand for another'. She maintains that young children will be modelling if they form any representation of the product they intend to make, such as hand gestures to suggest shape or form, discussion about what something will be like, drawing, painting, temporary arrangements with raw materials, or paper and card mock-ups. These last two 'models' may, for young children, also constitute the finished article, as modelling and making are very closely aligned, and the model may satisfy all the young child's intentions. The difficulty then is persuading the child that improvements may be desirable, without bruising the self-esteem on which future learning so much depends.

Design and technology move together. Design can enhance our everyday lives, our prosperity and our world, but technology makes it work. Design cannot exist alone (Barlex,1995). It is practised within different contexts and its realisation entails technology. Design and technology together are useful, productive and integrative, employing resources and information drawn from every field of knowledge. Design and technology is inventive because it demands the introduction of something new in a technical, mechanical or constructional sense. It is creative in offering aesthetics, style, and marketing directions that are innovative. It may also be described as expedient (Archer,1992) in that design and technology activities are justified by results rather than reasons: by their products rather than their processes. This is debatable as there are procedures within design requirements, such as determining specifications and evaluating results, that must be conducted rigorously if the end product is to be useful. The practice of the problem solving process, and its possible transfer across the curriculum, has been claimed as a valid rationale for including the subject in the primary school curriculum (NCC,1990). However, there are many more obvious and less controversial reasons to consider including learning through design and technology in the Key Stage 1 curriculum.

1.2 Problem Solving Strategies

From his research in primary schools, Kimbell (1994) has characterised the D&T tasks set for children at Key Stage 1 as 'cultural technology' based on topics such as 'homes' or 'ourselves', rather than 'problem solving technology' concerned with mechanisms and making things work. However, all design and technology is fundamentally concerned with acting creatively and imaginatively to meet challenges and tackle problems, and this is done continually throughout all design and make activities, whether they are done by engineers, professional designers, pre-school children at play, or pupils in the classroom.

A major reason for teaching design and technology at Key Stage 1 is that it enables young children to begin to learn to tackle difficult problems in a practical way. It enhances their problem solving skills, procedures and strategies, and enables the development of concepts. Problem solving in design and technology brings together purposefully procedural understanding and conceptual understanding (Kimbell,1994). However, there is still some confusion concerning the role of process skills in this

procedural and conceptual understanding. In a paper on improving children's performance in the procedures of D&T, Johnsey (1997) describes three broad interlinking areas about which primary pupils should learn. These are:

* *Practical capability,* involving an overall ability to solve practical problems from prolonged involvement in tasks over many years

* *Knowledge and understanding in design and technology,* such as the understanding of mechanisms and structures

* *Procedures of design and technology,* which he describes as the broad procedural skills such as identifying needs, modelling or evaluating, but also talks of as *process skills*

This distinction between the three areas of learning in D&T is helpful but needs some clarification. From his research, Johnsey provides a list of the procedural skills used by children throughout Key Stages 1 and 2:

* Investigating and exploring the design context
* Identifying needs and potential for design and make tasks
* Clarifying implications
* Specifying criteria
* Researching into the problem
* Generating ideas
* Modelling ideas
* Planning and organising
* Making the product
* Evaluating the process and product

He contrasts this list with a synopsis of the Designing and Making Skills for Key Stage 2, detailed in the National Curriculum (DES, 1995):

Designing Skills:	*Making Skills:*
Generate ideas	Select materials, tools and techniques
Clarify ideas	Measure, mark, cut and shape materials
Develop ideas	Assemble, join and combine materials
Model ideas	Apply finishing techniques
Suggest how to proceed	Suggest how to proceed
Identify strengths and weaknesses	Evaluate products
Indicate ways of improving ideas	Implement improvements

Johnsey finds that two of the key procedural skills that he identified, namely researching and specifying criteria, are missing from the National Curriculum list. He goes on to proffer the notion of design and technology procedural skills arranged in a toolbox, 'each section containing a set of tools or strategies'. He suggests that each pupil will develop a personal set of strategies for each section of the toolbox and learn to use them in different ways. The teacher's job will be to enable the pupil to develop a wide range of these tools and appropriate ways of using them differently in different circumstances. Although this suggestion does not take account of the fact that the strategies that

children use in D&T are often collaborative rather than purely personal, Johnsey, like many others (Kimbell et al,1991; Mayo,1993; McCormick,1996) have successfully begun to move away from the simplistic view that there is a single transferable process for designing and making that can be taught to all pupils and used in all situations. His model also begins to provide the basis for a set of identifiable procedures which might be taught and assessed by teachers. It also encourages the notion of personal creativity and imagination. Johnsey further suggests that, paying attention to one procedure at a time, it may be possible to 'sketch out a progression in each one'. He maintains that more research is needed in this area.

Johnsey's research was done in Key Stage 2 classrooms. By identifying and tracing children's strategies throughout Key Stage 1, the present study, detailed in the following chapters, aims to begin to satisfy the need to identify children's problem solving strategies at Key Stage 1. In this way it may also be possible to clarify a little the complex inter-relationship between:

* Children's skills, procedures, and ideas: related to the notion of an integrated designing and making process in the Review of the National Curriculum (DFEE,1999)
* Children's problem solving strategies: related to the process and product of designing and making
* Procedural and conceptual knowledge: related to design and technology capability.

1.2.1 Control and Change

Underlying problem solving in design and technology are a number of fundamental elements. These are: control and change, contextualisation, play and collaboration, and environmental considerations. These are embedded throughout the content of the subject, its practice, and the values of the teachers who teach it. They are fundamental to human endeavour and essential to operating successfully in the modern world. It is therefore important that children are introduced to them at an early age.

For children, meeting everyday wants, needs and challenges and striving to control and change their environment is the basis of design and technology education. Children want to know how things work. They strive to understand both human social systems and mechanical ones. Outterside's research (1994) has shown how young children learn first to represent the world through the medium of images and words, then the signs and symbols of drawing, and to imagine new possibilities through their play. They use role play in design and technology education to learn both manipulative skills and about the wants and needs of people within various social systems. McIntyre (1990) explains that in choosing a role play focus children begin to see a relationship between people, places and objects which enhances their design awareness and understanding of the world.

Kimbell et al (1996) observed that the raison d'etre of technology is 'to create purposeful change'. The ability to understand and believe in change is very important in learners. Dweck's research (1988) with seven and eight year olds distinguished between learners who were 'mastery oriented' and those who were 'helpless prone'. The former

were motivated by the desire to learn and understand, but the latter by performance goals and competing with others. Dweck found that the difference between the groups was based on the children's belief in 'fixed ability'. Those children who were helpless prone believed that their ability was fixed and that they would never 'get smarter', whereas mastery oriented children believed that it was possible to 'get smarter' at a subject by working hard. Believing in the possibility of change, then, is important for young learners.

In her work on problem solving with young children, Sylva (1993) used Dweck's ideas but found that personal control in setting tasks affected the outcome of performance. She classified children on a continuum between mastery and helpless types. She characterised mastery type learners as approaching problem solving in a confident, flexible and reflective way, while helpless learners avoided challenges and took failure to mean low intelligence. Sylva concluded that often the focus in schools is on extrinsic motivation. Young children want to please their teacher and avoid criticism. She advocated greater child autonomy or negotiation of tasks with teachers.

Baynes (1992) asserts that all small children display a high degree of design and technology ability even before they come to school. Through play they are constantly striving to shape and reshape their environment. They make choices on the basis of what they see and like in their immediate surroundings, and they manipulate objects and people in order to explore these. Ritchie (1995) suggests that in constantly looking for chances to explore new objects and situations children are both 'problem seekers and problem solvers' . They are curious about their environment at a very early age and try to influence, improve and change it. Both at home and in school young children are required to choose tools, materials and strategies appropriately for the task in hand. Children grow up surrounded by 'design' decisions every day. They are beginning to understand how some artefacts, systems and environments can be designed and made in the real world, and they come to the Infant classroom with some experience of designing and making through play and a desire to engage further in it.

Consequently, it could be argued that design and technology activity in school is very similar to ways of learning at home, and that as a 'new' curriculum subject described in the first statutory order (NCC,1990) it not only builds upon children's previous experience before they enter school, but should help equip them to tackle everyday problems after they leave. Siraj-Blatchford (1996) argues that in the early years of design and technology education it is essential that we make learning relevant, relating it to the child's own experience, previous knowledge and understanding, and developing physical capability and moral awareness. However, he goes on to suggest some very prescribed activities that would probably result in children's lack of ownership of the task, rather like painting by numbers. McCormick (1993) found that the consequence of this lack of ownership in older pupils was that they ignored multiple ways of problem solving and spent little time thinking or analysing. From the researcher's professional experience it seems that perhaps one of the most useful ways of sharing ownership of the task is to encourage pupils to identify their own technological wants and needs, as far as possible, and to work

towards sharing the setting of tasks that closely reflect children's own interests in familiar, yet challenging and lively contexts.

1.2.2 Contextualisation

The great value of learning through design and technology for young children is that setting of real tasks creates meaning and relevance and provides starting points for young children's thinking and action. In their small scale study of young children working on technology tasks, Garvey and Quinlan (1997) found that having a clear sense of purpose is very significant for young children's learning. Kimbell et al (1996) has also found that how tasks are set for children is very important, and argues that the context of the task affects a child's ability both to do and to review their work. In Kimbell's research with primary pupils he described three types of task. These are *contextual* or very open-ended, *framed* with some constraints, and *specific* or tightly defined tasks. The challenge for the teacher is to provide a balance of tasks for children, allowing them a certain amount of control but giving a framework of guidance when necessary, so that they do not flounder.

Johnsey (1997) maintains that young children feel a sense of purpose if they are encouraged to work to clear design specifications. He states that the product criteria need to be agreed at the outset of the learning activity and kept in mind throughout. Pupils should then be encouraged to check the progress of their work against these criteria throughout designing and making, and to evaluate their product at the end. Rogers and Clare (1994) have pointed to the power of the process diary as a tool to help children reflect upon how they have worked through a project. Many teachers have adopted the idea of a process diary to help children monitor and record their work as they proceed, but this must not result in mechanical recording that is tiresome for pupils and detracts from their enthusiasm for the work.

1.2.3 Play and Collaboration

Investigating the properties and uses of materials and tools is an essential part of choosing materials, and for young children this may include an element of play as they test and try out various resources. The enjoyment of sharing these experiences with a friend or in a group, and the freedom children may have for engaging in 'on task' and 'off task' play while working autonomously, may enhance children's motivation. Collaborative work also helps young children to de-centre and empathise with others (Kutnick,1990; Perret-Clemont,1980). Damon (1988) argues that the ability to take the perspective of another is critical to emotional and social maturity. Working together, children learn to deepen their concern for their family, and develop respect for others. They gradually form the social skills necessary to work in groups, including the ability to be self-critical and to accept criticism from others (Pitt,1991). This reflection is an essential requirement when evaluating the objects designed and made by others and those they have created themselves. It is essential in order to improve both the products and their personal and group technological knowledge and skills. Younger children at Key Stage 1 are often very

reluctant to be self evaluative, but Garvey and Quinlan (1997) have suggested that older children benefit from working with a 'critical friend' towards testing and modifying their products. Sometimes encouraging young children to create narrative about their product in the form of a story helps them to think critically about their work.

Understanding others' meanings or points of view is important for developing cooperative strategies, where help-giving and help-receiving are central. There may be different means of asking for and receiving help and these may be perceived in various ways by peers. Design and technology requires good communication skills used for practical purposes in the classroom. Most teachers see the value of children's cooperation in groups but in design and technology pupils are often asked to work together; indeed this was statutory in the first National Curriculum (NCC,1990). The UTA Research Project (Kimbell,1994) found that pupils at Key Stage 1 handled 'user' issues 'more than children at any other key stage' and easily empathised with users of their designs. They suggested that teachers build on this ability through negotiating the setting of design criteria by peer groups at the start of tasks and giving these criteria a high profile through discussion throughout designing and making.

1.2.4 Environmental Considerations

The Design Council in its formative series of publications 'Signs of Design' (1989) points out that starting points for technology education are all around us. They define technology very widely as 'everything we use to work for us' (ibid p3) but the tradition of good primary practice in the early years has always advocated learning aims and objectives that view the child and the immediate environment as the obvious starting point. Designing, making and using role play areas in the classroom helps children to understand social systems, such as the division of work in a supermarket or hairdresser's, and to begin to appreciate the fundamentals of buying and selling, profit and loss, and the value of human labour. Taking holiday details on a toy telephone in a role play travel agent's can help to foster communication and organisational skills, while taking orders as a waiter or waitress in a classroom cafe can encourage emergent writing in very young children. Design and technology can help children understand and relate to the environment they live in as well as enhance cross curricular skills and dimensions.

1.3 The Nature and Values of Technology Education

Views concerning the nature of technology education are many and varied. Perceptions often range from the narrow view of technology education as applied microelectronics, to the very broad perception in which technology education encompasses almost every creative, practical activity (Harrison,1994). However, all views concerning the nature of technology education bring with them attitudes and beliefs about the aims and objectives of education in general, and what it should achieve. Underpinning all perceptions of design and technological activity are value issues. This is argued powerfully by Layton (1992), who refers to values and value judgments as 'the engine' of design and technology. He explains that judgments about what is possible

and worthwhile initiate activity; and judgments about how intentions are to be realised shape activity; while judgments about the effectiveness and effects of the product influence the next steps to take. Value judgments, reflecting people's beliefs, concerns and preferences are ubiquitous in design and technology activity.

Layton (1994) explores how school technology itself has been shaped by a process involving some major value conflicts inherent in the views of various pressure groups with interests in the way technology is taught in schools. Such 'stake holders' include, at one end of the spectrum, those that hold an instrumental view of education, with national economic competitiveness and wealth creation as their main values, embodied in the call for pre-vocational schooling (Prais and Beadle,1991); while at the other extreme are 'liberal educators' such as philosophers and sociologists whose value position is that education should help children to construct and be initiated into the symbolic worlds of knowledge that we have created, one of which is technology. Others include engineers whose dominant value concern is to enhance the professional image of technology or, more precisely, engineering (Engineering Council publication,1992), while a powerful lobby group calling for global responsibility in the form of 'appropriate technology' believes that education should empower us with the knowledge, skills and values to control technological development (World Bank Report, 1993).

Perhaps surprisingly, Layton also includes 'women' as an extremely large and powerful pressure group who are contributing to our perception of technology education by approaching the question of values, and particularly moral values, from a different perspective. Gilligan (1982) and Franklin (1990) claim for women the ability to change the parameters of technology by viewing moral problems in terms of care and responsibility rather than the 'masculine' rights and rules.

If Layton is correct in his perception of the various influences that have so far vied to shape the design and technology curriculum, how have all these value positions affected the subject for young children? Certainly the first Statutory Orders (NCC,1990) formed part of a government initiative to heighten the economic profile of Britain in Europe. Economic functionalists and professional technologists perhaps found the Revised National Curriculum (DES,1994) a poor foundation for pre-vocational and skills based training, despite greater emphasis on specific knowledge and craft skills and the working of mechanisms and structures lacking in its predecessor. Whereas other interest groups, perhaps including some primary teachers, bemoaned the loss of the breadth and general problem solving opportunity in the Revised Orders (DES,1995) and preferred the original document. The Revision of the Orders (DFEE,1999) appears a breath of fresh air in comparison, with its integration of designing and making, and real world vision of creativity and innovation.

From the first National Curriculum documents, the Design Council was very influential in shaping the views of primary schools. Their formative publications, videos and exhibitions of children's work were seized upon by LEAs who were keen to provide INSET for their schools to help teachers make sense of this new and complex area. The emphasis here was on the process of design. The Craft Council has also used its

influence in primary schools but concentrates more on pupils as makers, in developing technical skills, and in providing schools with links to professional studios. If technology education for young children intends to develop practical problem solving ability, eventually preparing pupils to handle complex problems in their lives, what does this value position imply?

1.3.1 Values at Key Stage 1

The DATA leaflet 'Why Design and Technology?' (1995) was headed by the mission statement 'Preparing young people for living in a technological world'. In her address to the IDATER '96 conference, Ruth Conway questioned whether this was feasible, given the rapidly changing nature of our society. She highlighted the values inherent in manufacture and servicing for our consumer society and the values underlying the toys and games young children play with, their diet, clothes and how they celebrate. She maintained that technology is not value free in its use at home or in school; there is often a price to be paid.

Primary children may unconsciously appreciate the underlying message in the curves of Barbie or the muscles of Action Man. One of the dangers of school technology today is that it is shaped too exclusively by outside influence. The locus of control seems at times remote from educators, teachers and, perhaps most sadly, the capability and values of the pupils themselves. In sensitively introducing short evaluative activities of everyday products, some of this influence may be laid bare and some reclaimed for children and teachers.

The use of short 'evaluative and disassembling activities' (Statutory Orders, DES 1995) may have helped children to investigate familiar products and applications and also identify possible making skills that can be practised in 'focused practical tasks'. Both of these activities fed into and enriched longer design and make assignments (ibid). Now, sadly, disassembling has disappeared from the orders at Key Stage 1 (DFEE,1999). For some pupils at Key Stage1 the ability to appreciate values beyond their own likes and dislikes may not be as limited as some might expect. Constable's research (1994) indicates that they can explore values and differing priorities, thinking in terms of 'winners and losers'. They can also profit from activities that demonstrate that many of our own choices are based on unconscious values such as liking the colour or the packaging of consumer goods, or liking the things our friends like. Even very young children can begin to look at familiar products critically. The booklet 'Looking at Values through Products and Applications' (DFEE,1996) focuses on values inherent in the designing and making of products such as tee-shirts, Coke cans, motorways. In addition to focusing on evaluation of modern products this booklet provides a framework for looking with young children at historical production, and especially production which reflects the choices in society of those with power. Costume and use of textiles throughout history reflect social and cultural values. Attitudes to gender and childhood itself can be seen in costume throughout the ages.

However, when children are required to make qualitative judgments, we must be

careful not to adopt a passive view of their role as users of technology, but think also of how children can feel their own influence as consumers in demanding certain goods and rejecting others. Clothes can communicate personal style and preference when chosen by an individual, or a sense of togethemess when the same clothes are worn by a group of people. For instance, children may understand this feeling of togetherness with regard to school uniform, which is chosen for them by adults, but even young children are beginning to demand fashionable trainers now. This can form the basis of discussion when setting the design criteria with pupils at the start of a D&T activity. For example, what effect will the possession of such trainers have on friends, or the school's new hardwood floor? Drummond and Pollard (1995) explain that each child comes to D&T with their own personal value system. A child who designs a colourful carrier bag for her grandma's shopping may be displaying different values from one who designs a wheeled trolley for this function. Bearing in mind users, and the purpose for which a product is intended, may result in different responses, even from members of the same peer group working on a product together. When evaluating the designing and making of their own lemonade, a class of children are not of one voice in deciding which recipe they find most thirst quenching. Kimbell (1994) found that Key Stage 1 children handled user issues more than children at any other key stage, were aware of the diversity of user opinion, and easily empathised with the users of their designs.

Conway (1994) asserts that D&T should add to the quality of life and relationships and not merely to what we possess materially. She talks of developing in young children a growing sensitivity to the needs of others and the environment, and of also encouraging responsible decision making; for example, attitudes to waste and whether materials are renewable or recyclable. It is common for imported technologies to be recycled or reshaped to fit their new cultures by their hosts; for example, Indonesia makes sandals from car tyres, and Britain imports ginger jars from China to make lamp bases. Technology is far from static and neutral. It is formed and governed by its context and values. Experience and relationships of a society at any given time become encapsulated in its artefacts.

Eggleston (1992) has highlighted the powerful social pressures that for generations have differentiated technological achievement by race. He has pointed to the consequences of stereotyping and unintentional racism of teachers who do not challenge the popular assumptions surrounding the motivation, ability and cultures of their black pupils. It is important that from an early age children realise that Western society does not have a monopoly in technological achievement and indeed that there is no hierarchy but a vast richness and diversity. It is vital to avoid presenting other cultures and their technologies as in any way archaic or exotic (Mulberg,1992). Opportunities exist in early years classrooms for perceptive teachers to take account of different cultural beliefs and community practices, especially when children are working with food and designing and making large play environments.

A rapidly growing subject such as design and technology should provide enhanced equal opportunities for all pupils to succeed. For example, when designing a

moving vehicle, children with special needs may consider electric windows as essential while others may feel them a waste of energy. The requirements of children with special needs, and the ways in which technology has been adapted to suit them, may run contrary to the perceptions of other children and these can be recognised and used to underline the complex nature of values in design.

Values education is certainly a gender issue. There may be different values displayed by girls and boys in the classroom. It has been found that generally girls do better than boys in the more reflective areas of D&T work, whereas boys are better at generating ideas and modelling (Kimbell et al, 1991). Key Stage 1 research on Non-Statutory SATS found that girls were found to have outperformed boys in all but AT3 Making (Stables,1991). In contrast, Browne et al (1993) has found that girls and boys find difficulty in different aspects of design and technological activity at Key Stage 1. Boys were keen to tackle open-ended constructional tasks, for example using Lego, but girls were keen to attempt tightly structured, evaluative tasks, for instance making a card for grandma. They argue that girls need more time on their own to gain experience of things that are more familiar to boys such as wood and tools, and extra attention from the teacher so that they will not 'hang back'. However, the work of feminist writers such as Gilligan (1982) and the formative writing of Rothschild (1988) on women and the history of technology, suggest that we should provide opportunities for girls to define technological challenges, and respond to these in their own ways and on their own terms. Eggleston argued in 1992 that addressing aspects of gender differentiation is again a chance to make a new beginning in the primary school in a 'new' curriculum subject 'where few teachers have studied technology and few have taught technology' (p60). But should design and technology still be regarded as a new area of enquiry in the early years classroom? Now that it seems to be an established foundation subject in the National Curriculum, what is the modern challenge for teachers at Key Stage 1?

1.4 The Challenge for Teachers of Young Children

Until fairly recently design and technology seemed to be beginning to find its feet as an established subject in the National Curriculum. Then uncertainties for its future began to be felt. The primary curriculum from September 1998 required schools to place a sharper focus on literacy and numeracy. The Secretary of State proposed that primary teachers would no longer have to follow National Curriculum programmes of study in design and technology and other foundation subjects. This proposal would apply from September 1998 to September 1999, when a revised 'slimmed down' curriculum would be introduced. Teachers still needed to 'have regard to' the National Curriculum programmes of study in design and technology, but would not need to follow them in detail. The document 'Maintaining Breadth and Balance at Key Stages 1 and 2' (QCA, 1998) reduced each foundation subject to one side of A4, and was expected to be a model for the way the whole National Curriculum was to be reshaped for the year 2000.

Many found this news disturbing, not because they wished to retain the 1995

Order, but because schools were just beginning to gain confidence in planning and implementing it (OFSTED, 1997) and at that time, with the focus on literacy and numeracy hours in primary schools, there was some fear for the survival of D&T as a curriculum subject. Less confident teachers took the opportunity to considerably reduce the number of units taught across the key stage, especially at Key Stage 1 where budding literacy and numeracy seemed so important. However, despite the confusion at that stage, in the event the review of the D&T curriculum proved an opportunity to revise thinking and update theoretical perspectives. Although the first review of the D&T National Curriculum did not arrive until November 1999 (DFEE,1999) this gave time for discussion and consultation, and there was found to be fresh impetus in discussion, and agreement about the meaning of D&T education for the new millennium. There was felt to be a real need to move away from the 'National Curriculum speak' of the previous Order and to create a document that would convey the unique contribution of D&T to the curriculum. Debates by the QCA working party revising the curriculum for 2000 were concerned to portray design and technology as a subject that prepared children to face the future positively and optimistically and tobecome autonomous, creative, and proactive problem solvers. They were also concerned with children working not only as individuals but in collaboration with others to develop personal capability through their own designing and making, and through a critical awareness of manufacture and marketing. There is now further time to trial the requirements and dissemination materials. Reassuringly, from September 2000, for Key Stages 1 and 2, the new programmes of study need to be followed in full, although sadly they do not always reflect the spirit of the review procedure.

The new emphasis on problem solving is heartening. Interestingly, this is the first time since the formative Interim Report (DES,1988) that problem solving has been mentioned explicitly in D&T National Curriculum documentation. Since the 1980s there have been many interpretations of D&T and the problem solving process embedded in the structure and content of the various National Curriculum documents. Following a large APU study in secondary schools (1987), problem solving was seen as a spiralling process of design, make, evaluate and review. Other early models of problem solving laid out a linear approach (Black and Harrison,1985). The working group's proposal to the Secretary of State (1989) proposed a simple loop. This model maintained that evaluation at the end of designing and making implied modification, or provided new problems which started the process again. The Order for Technology (NCC,1990) provided a fairly simple circular model, reiterated in NCC INSET videos for Key Stages 1 and 2 (1991). This material often reflected a greater concern for 'doing all the stages in the diagram', than for 'combining a growing range of capability in a way which reflected individual creativity and confident and effective working methods' (APU, ibid). Further practice using this early model revealed that it failed to recognise the need for continuous pupil research, for generation of ideas, and for regular evaluation of these ideas as they emerged. Models became more and more complex and teachers more confused as researchers began to recognise the complexity of the problem solving process. Johnsey (1995a) identified seventeen

models of the D&T problem solving process from the literature, but questioned where these models came from, on what evidence they were based, and how accurately they described the pupil designer. He found a surprising consensus among the authors of these models about which procedures were included in problem solving, but suggested that there was little research evidence to support their claims.

Hennessy and McCormick et al (1993) highlighted the confusion when they wrote of the 'myth of general problem solving capability'. They questioned transference of learning across contexts and between school and daily life, and specifically that a general problem solving process was being fostered through design and technology activities in schools. They pointed to a 'veneer of accomplishment' and a mechanical approach to solving artificial problems as a consequence of an 'over emphasised, narrowly perceived design process' (ibid). To be fair, the research project that resulted in these assertions was carried out in secondary schools where design and make projects were broken down for pupils into single lessons, each covering one aspect of the design loop. Consequently, there was very little opportunity for the process to be taught or assimilated as a whole, or for the pupils to decide when and if they should use certain problem solving strategies. The constraints for these pupils were overwhelming from the start.

At Key Stage 1, teachers often have the opportunity to allow children greater control over their learning so that they can devise and use problem solving strategies at will during a complete design and make assignment over an afternoon or whole day. This prevents unnatural fragmentation of the process and allows children greater freedom to take responsibility for their own learning. The UTA research study (Kimbell,1994) expected to find evidence of a gradual transition of responsibility from teacher to child as pupils moved through the four key stages, but this was not so. Their research traced teachers either supporting or directing children, from Year 1 of the infant school to Year 7 of the secondary school, and found that only in Year 2 was there an equal balance of support and direction by the teacher. Indeed, despite a fairly even start through the primary school, when teachers used both support and direction in lessons, at Year 7 when children entered secondary school, teachers swung radically towards a vastly greater directional stance, and children in Years 6 and 7 reverted to a much greater level of dependency on the teacher than when they were in Year 1 at primary school.

The confusion concerning the design process was averted by the publication of the Revised Orders (DES,1995). OFSTED (1992/3) had reported inadequate implementation and, with the Engineering Council's publication 'Technology in the National Curriculum' (1992) the NCC made the case for revising the Order. This time the focus was on the product rather than the process of designing and making, with the accent on producing 'high quality products fit for their intended purpose' (DES,1995). In the Revised Order for Design and Technology (DES,1995), the four attainment targets, often thought of as comprising the design process, were reduced to two: Designing and Making. Although the process was still implied in the ATs, the focus was now on identifying and learning skills, in short disassembling and evaluative tasks and focused practical tasks. These were used to support longer design and make assignments.

The revised (1995) curriculum, with its focus on high quality products however, meant that too often pupils spent time 'making' without sufficiently analysing the task at the outset or assessing their own performance. This was often due to the fact that teachers failed to share design criteria with children or refer to them throughout. Teachers then expected product evaluation at the end of the task without focus on design specifications. It is difficult for teachers to unlearn the simplistic models of the design and make process offered in the literature, which seem to make the management of D&T so straightforward in theory. Process diaries, advocated to help organise large groups of children towards setting criteria and recording their activities, sometimes act only to reinforce a simplistic process and distract children, who hurry the writing in order to get back to more active designing and making.

Many Key Stage 1 teachers find National Curriculum documents difficult to translate into meaningful tasks in the classroom. Anning (1997) points to a number of conceptual and pedagogic problems still to be resolved by teachers because they are often unclear about whether they are asking children to design and make a real object, a prototype, a mock-up or a model. They may also be uncertain about when to intervene to teach the knowledge and skills that should form the basis of children's creativity and invention. Teachers may also find these practical activities hard to organise and manage with a large class of young children. Space, availability of tools, INSET and general support from coordinators or school policy is often lacking, and D&T sometimes gets overlooked entirely in an overcrowded primary curriculum focused on the introduction of the literacy hour and the numeracy hour. The NACCC Report (DFEE,1999) laments that there often seems little room for creativity. To compound the problem, when isolated D&T lessons are taught, teachers may find that pupils become over-excited and have little experience to draw upon of working safely with tools and materials. These pupils, like their teachers, have not had the opportunity to build a base of D&T knowledge and skills that would enable them to tackle or teach the tasks at the expected level. OFSTED (1995,97) has stated that good standards in design and technology are mainly determined by the teacher's command of the subject. It is important to consider how knowledge base affects the current organisation and management of D&T in schools and influences the development of children's capability at Key Stage 1.

1.4.1 Teachers' Subject Knowledge

Firstly, it is important to identify in an overview what teachers at Key Stage 1 should teach and children should learn. Essentially there are three inter-connected areas which may be summarised as follows:

* The process of designing and making, which includes an understanding and experience of how to proceed with a design and make activity in a variety of familiar contexts. This requires that children should devise and use a number of broad procedural skills and strategies, such as generating ideas, communicating these ideas, making suggestions about how to proceed, and evaluating their products.

* The concepts or knowledge and understanding involved in design and technology, which includes unique areas such as products and applications, quality and technical vocabulary, as well as knowledge and understanding shared by other aspects such as mechanisms and structures and health and safety.

* The skills or practical capability, involving an understanding of how to handle materials and tools, such as assembling materials, joining and finishing.

These are by no means discrete areas but merge, emerge from, and feed into each other as children develop their designing and making capability. Johnsey (1997) argues that without a base of knowledge and understanding the opportunities for primary pupils to develop capability is severely inhibited, and maintains that this is important as this practical capability is an aspect that is unique to D&T.

Frequently, however, pupils fail to progress in their development of design and technology capability. OFSTED (1997) linked this to teachers' lack of both 'subject knowledge and practical expertise'. Curriculum planning was also criticised in some schools for failing to ensure full coverage of the National Curriculum and that the work was progressively demanding. Edwards and Ogden (1998), in discussing research with PGCE student teachers, stressed the key role that subject knowledge plays in informing teacher intentions, the organisation and representation of knowledge in planning, and the quality of teacher evaluation and reflection.

Discussing subject knowledge in D&T, Garvey (1996) referred to a more detailed analysis of subject knowledge undertaken by Schulman (1986), who identified seven subject knowledge bases as necessary for effective teaching . These were:

* content knowledge
* general pedagogical knowledge
* curriculum knowledge
* pedagogical content knowledge
* knowledge of learners and their characteristics
* knowledge of educational contexts
* knowledge of educational ends, purposes and values.

Ellis (1995) developed this analysis further and highlighted the following components for general teacher education across the curriculum. Relating them to teachers' subject knowledge in D&T provides this list:

* Distinctive aspects of the subject. These are the beliefs and values associated with the subject, its role in modern society, and the subject's relationship to and difference from other subjects. This would include the special relationship of D&T to science and art, and its links with mathematics, and communication skills. It also includes aspects of historical technology, technology and religious and cultural issues, and social, moral and aesthetic values.

* Knowledge about the management of learning, that is, the knowledge of materials and resources, organising the learning environment and working with other teachers. Teachers who lack confidence in D&T content may give reasons concerning lack of space for tools and equipment in their classroom. Teachers sometimes have little experience of handling tools for wood, metal or other hard materials, and therefore cannot teach others. They worry a great deal about health and safety risks, and teachers with little intellectual subject knowledge often over-compensate with intensive classroom management and control.

* Substantive content-knowledge or the concepts of the subject. This relates to the knowledge and understanding involved in design and technology, which includes unique areas such as products and applications, quality and technical vocabulary, as well as knowledge and understanding shared by other subjects such as mechanisms and structures, and health and safety, in science. This knowledge base affects teachers' confidence in teaching in the classroom, and also influences the quality of curriculum planning.

The knowledge, skills and understanding required to attain design and technology capability for teachers are set out in a detailed research paper published by DATA (1997). It identified the content for D&T courses, starting from initial teacher training, and lists the minimum competence for NQTs to teach design and technology in primary schools (Tier 1), and additional competence for teachers trained to support colleagues in post as design and technology specialists (Tier 2). If all NQTs are trained in accordance with this document then design and technology in schools will begin to be based on ensuring high standards in teaching competence. This basic knowledge also needs to be provided as INSET for existing teachers. Inspectors (OFSTED,1997) drew the distinction in primary schools between those schools where teachers had received design and technology INSET and those where teachers had no such support. Inspectors noted that teachers with support were more confident and competent with higher levels of achievement in organisation, planning, and teaching.

* Process knowledge, or the method of inquiry in the subject. The process of designing and making includes an understanding and experience of how to proceed with a design and make activity in a variety of familiar contexts. This requires that children should devise and use a number of broad procedural strategies, such as generating ideas, communicating these ideas, making suggestions about how to proceed, and evaluating their products.

Setting tasks from real contexts or open-ended tasks with 'authentic dilemmas' has always been part of the child-centred ideology of the early years classroom. The Non-Statutory Guidance for D&T (NCC,1990) was clear that 'aspects of good technology already exist in most primary schools' (p B3). Infant teachers have always tried to share control of learning with the children by allowing groups to set their own tasks, so 'putting

children in the driving seat' (NCC,1990). In a recent article, Solomon (1997) argues that teachers should aim for a balance of 'sharing the locus of control' and 'instructional density' when teaching, in order to encourage children's motivation.

Open-ended work with children is very challenging for teachers, and they need to make time for both individual children and groups, in order to allow them to devise and use their own ideas and strategies. They need sufficient understanding of how the design and make process is 'deconstructed' (Garvey,1996). This is not only, as Bowen (1996) maintains, in order to break it into manageable chunks, or lessons, so that necessary skills might be taught before children tackle the task, but also in order that teachers might intervene purposefully by providing helpful, critical but supportive comments on pupils' developing ideas and strategies.

* Pedagogical content knowledge. This concerns aspects of the subject relating directly to learners, for instance the way children learn, the ways in which adult knowledge about learning is used in teaching, and teachers' knowledge of the appropriate means of assessment and evaluation.

Helping children to think about the way they themselves learn is invaluable, and D&T can aid in this early self-awareness or metacognition. Kimbell et al (1996) have pointed to the transparency of thought demonstrated by older pupils' design folders. Young children's process diaries, if used sensitively, can fulfil a similar role of enhancing children's conscious awareness of their thinking. Hennessy et al (1993) suggest that teachers must endeavour to make children's problem solving processes explicit. Asking young children questions about what they are doing and what they will do next, and encouraging children to question, is valuable teacher intervention. Also, consciously encouraging peer questioning and evaluation, and requiring children to assess and monitor their own progress, should help them become aware of what they are doing and why. However, in order for teachers to discuss young children's problem solving strategies with them, teachers must first identify these strategies.

Constructivist theory (Kelly,1955; Ausubel,1968) indicates that children come to almost every learning situation with their own ideas, and teachers may feel that they should take account of these ideas. Despite this, there is still little research evidence to support how children learn to design and make (Anning, 1997). Yet it is important that Key Stage 1 teachers understand the problem solving skills and strategies that young children bring to design and technology activities in school, so that they may have the opportunity to match them to National Curriculum expectations and build upon them if appropriate.

McCormick (1999) has pointed to the role of 'qualitative knowledge' within D&T capability. He has argued that children need to combine both procedural and conceptual knowledge and 'device' knowledge, and to reason qualitatively about these. Schulman's (1986) subject knowledge classifications have been listed earlier. However, Edwards and Ogden (1998) suggest that Schulman's classifications may be limiting because they focus on knowledge structures rather than knowledge construction. Schulman also explored

the construction of knowledge as he analysed the forms in which these knowledge bases are held. These were: 'propositional knowledge, case knowledge and strategic knowledge.' These forms determine how teachers approach each of Schulman's previous categories, but Schulman suggests that it is 'strategic knowledge' which is the hallmark of a professional. It is strategic knowledge and understanding which Schulman suggests is linked to professional judgment about which strategies to use when coping with problems or in a crisis. It is this knowledge that provides 'deep' understanding.

1.4.2 Extending Teachers' Knowledge Base

So what support do teachers at Key Stage 1 need in order to enhance their subject knowledge and improve the development of children's capability? To summarise, it seems useful to relate aspects of pupils' technological capability (from Scottish CCC, 1996, pp 8, 9) to teachers' own learning. Teachers may need greater:

* Technological confidence: an ability to tackle technological problems with a confidence based on secure knowledge, skills and understanding of the subject, a pro-active approach to challenge and intellectual risk, and a willingness to negotiate and share control with learners.

* Technological perspective: an appreciation of the values that shape real world and school technology, of the complexity of decisions involving cultural, economic, ethical and functional aspects of design products, and the ability to begin to communicate this to pupils.

* Technological sensitivity: a frame of mind which strives to make personal sense of key features of the D&T curriculum and relate them to the specific needs and circumstances of children in their care. This means starting from young pupils' social relationships, environment and interests and building upon their own intuitive problem solving strategies.

* Technological creativity. This includes using imagination to be unconventional and inventive when practising and teaching D&T; the ability to analyse, evaluate and modify alongside children and to make thoughtful and creative decisions; a belief in the possibility of change both technologically and personally; and a willingness to consider and embrace change in teaching methods using research evidence and action research opportunities.

1.5 Summary

To summarise the reasons for teaching problem solving in D&T to young children, and the challenges involved for teachers and researchers: tool-using may be ranked with language use as a fundamental human characteristic, and practical problem solving is a basic necessity in everyday life, vital for our survival. At home children gain certain imaging and making capability. When they enter school, designing and making as part of the curriculum is the natural continuation of this. It links practical and intellectual knowledge, skills and understanding. Working on authentic, real life problems links learning in the home and the classroom; it helps young children to see the relevance of education to their everyday lives and provides a genuine reason for learning.

Designing and making in school can enhance play and collaboration, encouraging teamwork and helping children to empathise with others and understand their needs. All children possess, to at least some degree, a need to exercise control over their own learning and their environment. Through design and technology education they can be encouraged to imagine change, both in themselves and in their surroundings, and to feel the power and self-esteem that comes from being creative and inventive, from making choices and preferences, and exercising judgment about things, people and places.

Teachers need to understand design and technology to see the growing possibilities for children in the modern world. But in order to do this effectively they must leave their 'comfort zone' to tackle challenges that force them into new areas (Kimbell et al,1996). It is evident that many teachers suffer from a lack of confidence when teaching design and technology, and it is a cause for concern that this has remained unchanged over the last decade. In 1989 results of a national survey of primary teachers in a Leverhulme project showed that only one in seven felt competent to teach technology (Wragg et al,1989). Almost a decade later HMSO (1997) observed that 'early progress in D&T in nursery and reception slowed in Key Stage 1, and more so in Key Stage 2'. Nursery and reception teachers were seen to support and extend children's own choices in learning through play. Children were observed to come from these learning environments with spontaneous problem solving strategies and skills in design and technology, but teachers at Key Stages 1 and 2 need to be helped to recognise and build upon these.

The nature and values of D&T that make it unique, challenge young pupils and their teachers. In the primary curriculum there is an urgent need for greater professional awareness, knowledge and understanding. Since its introduction in March 1990, design and technology has been the centre of much confusion and fierce debate. The subject is still evolving but we are at the point where we should begin to be much clearer about what teachers should teach and pupils should learn. This chapter has made a case for more detailed research. Young children enter school with great potential for learning through practical problem solving in design and technology. This study aims to build on this by attempting to identify and classify young children's problem solving strategies and trace these throughout Key Stage 1.

Chapter 2
The Theoretical Framework

Introduction

This chapter explains the theoretical basis for the study. Research into development of children's collaborative strategies needs to be situated within a theoretical framework that encompasses what we know about children's psychological and social development, and particularly the notion of collaboration in problem solving, since this is an essential requirement for working in design and technology. The research of Perret-Clermont (1980), Doise and Mugny (1984) and Galton (1999), on children's cooperative learning is combined with Vygotsky's ideas on social cognition, and Piaget's constructivism, to discuss how groups of young children learn from each other. The impact of gender on this collaboration is related to Goffman's (1979) research. The work on the zone of proximal development, extended by Rogoff (1990) in her idea of the child as apprentice is also discussed. However, a less passive view of the child as problem solver engaged in activities which present authentic dilemmas in the work of Lave (1992) may seem appropriate. This situated cognition stance offers a view of cognitive processes that differ according to the domain of thinking and the specifics of the task and context. It values the intimate connection between knowing and doing and views learning as a process of enculturation, through shared activities, into a community of practice (Wenger,1991). Elements of this literature are discussed in relation to learning in design and technology as it focuses on three essential aspects of the activity. It centres on how the context of a task affects children's strategies during problem solving, how children might be inducted into skills and processes which draw upon industrial and cultural models and, how the content of knowledge, skills and understanding of technological activity is introduced to children.

The following sections synthesise these theoretical approaches and relate them to young children's learning in design and technology in the classroom.

2.1 Piaget's Work

Piaget was one of the first to provide a firm research base for acknowledging a view of learning centred on active experience. Although others had also put forward this idea, Piaget's investigative tasks with young children provided the first evidence that children construct their own knowledge through action, and that this knowledge changes over the years and is different from adults'. Piaget is often thought to have been mainly concerned with individual learning, but Bliss (1995) points out that it was Piaget's philosophical interest in knowledge, and how it developed and changed, that led to his work with children, and not a psychological concern for children as individuals. Rather, he used them to study the general development of knowledge and to describe the laws that govern that development.

Piaget's investigative tasks with children led to a stage theory describing their

intellectual growth. These stages have been used as a tool to measure children's development, and Piaget's ideas have formed the basis of many of the science and mathematics activities in primary schools in the1990s. These ideas have also been influential in the formation of the primary design and technology curriculum, because Piaget recognised the extent to which children's interactions with the world around them contribute to their own construction and structuring of knowledge.

The following pages focus on relevant aspects of Piaget's work, looking in depth at his constructivist stance, his interest in the development of knowledge, and the context of his investigative tasks with children. These will be related to design and technology education. Finally, the challenges to Piaget's position are discussed.

2.1.2 Piaget the Constructivist

Piaget was one of the first proponents of Constructivism. He saw young children as constructing their own knowledge during activities. Piaget said:

> 'The essential functions of intelligence consist in understanding and constructing, in other words in building up structures by structuring reality.' (Piaget,1969, p6)

This presents a picture of an active child who is not just an interpreter of the world but a constructor of knowledge. Moreover, this construction comes about as 'a direct extension of our actions' and by using

> 'instruments of thought, so that intelligence consists of executing and coordinating through an interiorized and reflective form, and is interiorized actions' (ibid).

Therefore, children use logical, mental processes as 'tools' to understand and re-create knowledge through practical experience.

Case (1992) supports this idea by suggesting that Piaget's view of children's development was one of generalised intellectual competence, in that the child constructed theories about the world as a result of applying a set of 'logical tools' of increasing generality and power. This concept building progressed by processes of assimilation and accommodation. These happened together, allowing both internalisation of ideas from new situations, and the adjustment of these ideas to incorporate other ideas when similar situations occurred. Ebbeck (1996) states that in this way children were seen as continually modifying or building upon existing knowledge, and revising their thinking when faced with discrepancies between their existing view of the world and new information. Bliss (1996) explains that there is just one process: equilibration, which has assimilation and accommodation present together. This can be illustrated at the conceptual level in problem solving, when difficulties are encountered so that existing mental schemes are challenged and thrown into disequilibrium by new data or

observations that do not fit. Desforges (1995) maintains that this creates the cognitive conflict that is essential for the subsequent reformulation of a new, more comprehensive scheme, and conceptual change. Design and technology tasks often involve cognitive conflict that is essential for tackling difficulties and coming to terms with the challenges of problem solving, but Karmiloff-Smith (1984) argues that conceptual change comes rather from success in practical activities after tackling task difficulties. Then the child tries to reflect upon and understand how this success was achieved.

2.1.3 Piaget and Intellectual Development

Piaget saw development as involving progression for the pupil through four main periods: sensori-motor, pre-operational, concrete operational, and formal operational. However, he was interested in the development of reasoning in general and did not see stage theory as the most important part of his work, but used stages as analytical tools in understanding intellectual development. Light et al (1994) point out that for Piaget, the importance of direct activity holds true for the young infant as much as for the older child, and even at later stages of development when children are able to rely on mental images and language, thinking itself is still seen by Piaget as internalised action. Children are perceived as self-motivated, active learners who think qualitatively differently from adults, and whose development is influenced by environmental experience (Piaget,1962).

Piaget's interactive emphasis on development stands in direct contrast to behavioural accounts, such as that of Skinner (1953), where the child is essentially viewed as a passive recipient of environmental influences. These ideas about the centrality of the child's own direct experiences map neatly onto educational notions about the need for children's own direct involvement in learning: that they should be given 'concrete experiences' and discover things for themselves. One of the defining characteristics of design and technology is that it enables pupils to gain access to complex concepts through concrete means (Kimbell et al,1996; Johnsey,1997). Concrete access enhances pupils' learning opportunities. Piaget (1971) was one of the first to recognise this by distinguishing concrete and formal operations. The five to seven year old children in the present study are, in Piagetian terms, moving from the pre-operational stage to the concrete operational. They are striving towards being fully intellectually operational by concrete means. In a sense, designing is concrete thinking, and young children may be seen to move towards this by a growing ability to represent objects, systems or environments through symbols or differentiated signs. Symbolic role play in D&T activities is an example of this process, as are drawing and planning, either on paper or by placing materials together to represent form.

2.1.4 Building on Piaget's Work

Van de Veer (1996) reminds us that among the people who first followed Piaget's work on intellectual development with great interest, and replicated some of his research in the field of language and thought, was the Russian psychologist Vygotsky, then virtually unknown. Despite disagreeing with him on a number of points,Vygotsky realised

that Piaget was then probably the most important voice in the field. One of the major points of disagreement was that of 'egocentrism'. In their first reply to Piaget's work, Vygotsky and Luria (1930) argued that the function and fate of egocentric speech was still unclear. Vygotsky thought that Piaget's ideas derived from his observations of children engaged in 'collective monologues', rather than true dialogues, and took this behaviour to indicate that young children, owing to their egocentricity or entrapment in their own point of view, are not even trying to communicate. However, Vygotsky later (1934), maintained that egocentric speech appeared most frequently when a child was confronted with a difficult situation and was directed towards the solution of a problem. The child first tries to solve the problem verbally in order to organise subsequent activity. Thus, egocentric speech has a specific organising function.

In recent years, however, a variety of other evidence has inspired a re-examination of Piaget's theory of early childhood thought processes (Donaldson,1978; Case,1992; Fischer,1995). As Piaget first discovered, children's thinking is often dominated by the inability to decentre or see things from another's point of view. In design and technology this affects their inclination to identify the wants and needs of others when setting criteria for design and make tasks. However, a variety of studies seem to show that young children are not so limited in their ability to decentre as was first thought (Flavell and Miller, 1993; Borke, 1975). On the basis of similar results, Donaldson (1978) suggests that three to six year old children can display non-egocentric perspectives, but the motives and intentions of the characters involved in the problem must be clear, so that the task makes what she calls 'human sense'. Similarly, when setting D&T tasks it is easier for young children to devise task criteria if they understand, perhaps in story form, the human reasons for creating the technology. Piaget's work was the first to acknowledge the importance of seeing things from another's perspective. When talking of young children, Harris, (1989) writes:

> 'Ever since Piaget carried out his classic research in which children were asked to imagine different perspectives on a mountain scene (the so called three mountains task) visual perspective taking has been seen as a key component of children's ability to put themselves in another's shoes'.
>
> (Harris, ibid, p 210)

Within design and technology education perspective taking is important, because in D&T children are encouraged to understand the needs and values of others as users and consumers, and recognise the importance of being aware of different views on a problem.

2.1.5 The Context of Piaget's Investigative Tasks

Piaget is sometimes criticised for requiring children to demonstrate context-free thinking of the type often expected in schools, and Donaldson's important work on disembedded thinking is often cited as a critique of Piagetian theory. However, the research itself owes much to his work, as Donaldson (1978) was the first to acknowledge.

Through her research, Donaldson shows how context bound young children's thinking really is. Their ability to solve problems depends on a variety of factors over and above their skills, such as the way in which the problems are presented, the language used, and the relationship between peers or adults present. Donaldson provides evidence which shows that young children can be remarkably competent thinkers when that thinking takes place in an 'embedded' context or one that makes sense to the child. Children's difficulties arise when they are required to solve problems in 'disembedded' contexts but, as Donaldson argues, this is precisely the kind of thinking often required in school mathematics, reading and science lessons. Design and technology lessons may be different as they use real and relevant contexts from which to draw tasks or problems, hopefully helping children to bridge the gap between everyday and school type thinking.

Piaget was well aware that a child's performance could vary from one version of a problem to another, even though the problems seemed to require the same logical operations, but he believed that subtle differences in the content of the task, for example mass, substance, weight or volume, accounted for this horizontal 'decalage'. He was also aware that the interview technique itself might produce apparent unevenness in performance, especially in young children who were still novices in the use of language (Piaget,1929/1979) but he believed that children could progress through developmental stages at their own rate, although he was not particularly interested in teaching, only in evolution of knowledge. Piaget knew that children could perform well on tasks set in familiar contexts but wanted to see what they made of more difficult tasks. As subsequent educators have found, setting problems in familiar contexts for children makes a substantial difference to their understanding. Design and technology problems are rooted in contexts familiar to young children, such as home and school, and move gradually to local community and towards unfamiliar contexts such as commerce and industry as children grow older.

2.1.6 Challenges to Piaget's Theories

In 1967, in a foreword to a 'critique of Piaget' by Sullivan, Ausubel wrote that it was a great pity that the amazing prolific observations and theories of Piaget, regarding cognitive development, have been criticised by modern theorists and practitioners, in 'the overstated, oversimplified and oversold manner of a fad'. He accused educators of putting Piaget's work through the 'intellectual mangle until it became unrecognisable'. In her opening address to the 1996 Warwick International Early Years Conference, which focused on the work of Piaget and Vygotsky, Ebbeck endorsed these comments, agreeing that in many ways they still hold true today. Piaget's work is often understood as the opposite in meaning to its original intent.

Coates (1996) considered the point that theories are influenced by the cultural values and beliefs of a society at any one time, and may therefore be applicable to one society and for one purpose. When Piaget's work first came into prominence it was at a time when the behaviourists' theories heavily influenced practice. Piaget's theory, that children actively construct knowledge as they manipulate and explore their world, created

enormous interest and much ensuing research based on his work. Siefert (1993) writes that present structural theorists borrow Piaget's emphasis on self construction. Also, Piaget's stage theory is now understood more flexibly, and new theories extend his work by concentrating more on how local cognitive structures are built, rather than on generalised views of, for example, structuralism.

The educators whose work has been touched upon earlier (Donaldson,1978; Borke,1979; Light,1979), have greatly contributed to our understanding of children's development by challenging Piaget's findings, specifically on the point that children's intellectual capacities are far greater than Piagetian tasks show. It is interesting to note, however, that according to Gardner:

> 'informed observers now concur that Piaget was actually describing the development of habits of mind gained in school, and Piagetian-style formal operational questions make little sense when posed in a non school setting' .
>
> (1991, p105)

This highlights the difference between children's performance in and outside school, and raises questions concerning 'school knowledge' and 'everyday knowledge'.

As already indicated, it has been found that there are contexts in which children will think at higher levels than measured in standard Piagetian tests, so that given the right conditions, young children can demonstrate competence considerably in excess of that which Piaget's test results indicate (Tamburrini,1982). Also, Piaget has been widely criticised for using children's 'mistakes' to gain insight into their thinking and devising tasks to 'catch children out'. However, it is quite the contrary and a gross misunderstanding of his work. Piaget was primarily interested in the evolution of knowledge, and he wanted to work with children in order to understand every step in this evolution. He saw each step as crucial, important and to be valued, not seen as a mistake, but Piaget's investigative tasks were always difficult for children because he wanted to see how far they could go in their understanding of the task, or what was their way of making sense of it. In D&T we do need to give children opportunities to correct their own errors, to be proactive and courageous in the face of challenge, and to be self-evaluative and act to promote change. Mistakes, difficulties, obstacles and risk are fundamental characteristics of D&T problem solving. They are the focus that challenges children's preconceptions and stimulates their thinking and learning.

Perhaps most of all Piaget has been criticised for not relating his research to the real life experiences of children. Rogoff writes (1990) that Piagetian research devoted little attention to the role of the social world and although Piaget dealt with social factors, including peer interaction in adolescence, there was little investigation into how children's social interactions contributed to their cognitive development. Despite this, Piaget always emphasised the active role of the child in the environment and in his later writing, acknowledged the importance of social factors in cognition. As Ebbeck (1996) reminds us, 'Piaget did not imitate anyone; others imitated him'.

Today, so many theories, including multiple intelligences, information processing

and social cognition, have their genesis in his pioneering work. Perhaps one of the greatest differences in theorists' beliefs now is the importance of sociocultural context, and adult collaboration in the child's construction of knowledge. This was underestimated by Piaget as he did not really have a direct view on teaching. So, although it was Piaget who showed us that young children bring everyday knowledge to school learning, it was the work of Vygotsky on social cognition that emphasised the important role that teachers and peers play in the support and extension of that learning.

2.2 Vygotsky's Ideas on Social Cognition

It was the power and insight of Vygotsky and his team of researchers who first focused most directly on a sociocultural approach to the mind. They created an account of human mental processes that recognised the essential relationship between cultural, historical and institutional settings. Although Vygotsky was born in the same year as Piaget, it was not until the late 1960s, and in the 1980s revival of interest, that his work made a unique contribution to education. This was mainly because he died as a young man and at that point his work was censored in Russia.

Wertsch (1991) suggests that there were three main themes in Vygotsky's writing. The first theme was cultural-historical in nature, with a reliance on genetic and developmental analysis. The second was a guided problem solving theme, concerning the claim that higher mental functioning in the individual is derived from social life, and the third central theme in Vygotsky's work was that human action is mediated by tools and symbols. All three themes involved perceived interrelated developmental levels of interaction between the individual and environment (Scribner,1985). This section of Chapter 2 aims to explore all three themes and relate them to the present study.

2.2.1 The Cultural-Historical Theme

The first theme was a reliance on genetic analysis. This entailed not only genetic development but phylogenetic development, or the slowly changing history of the species. It also entailed microgenic development, or the individual's moment-to-moment learning in problem solving situations, but most of all it involved sociocultural development, or the changing cultural history mirrored in the technology of a society and passed on to individual learners over time.

Vygotsky (1978) believed that biological and environmental factors not only shape children's development but that how they influence children depends on the way they combine in a specific cultural-historical context. He pointed out that activities and patterns of living are shaped by the experiences of earlier generations and passed down through their culture. Cole (1996) describes this as 'the history of the child's social group crystallised in the present, in the form of its culture'. Here Cole views culture as 'human designs for living', based on the accumulated knowledge of people encoded in the language of their artefacts, social systems and values. This underlines the part played by technology, as human endeavour, on the development of society, and in turn on the learning of children within it.

Bruner and Haste (1987) explain that the 'set of frameworks for interpretation available to the growing individual, reflects the organising consciousness of the whole culture'. Therefore, learning through design and technology can be viewed as the individual child making sense of his or her personal experience, but also being initiated into 'the ways of seeing and doing' which have been established, and tried and tested, by the technological community. It follows that young children's problem solving strategies can only develop within the boundaries of the cultural and technological context. They are constrained by the existing body of technical knowledge, and what is acceptable within the social rules of the classroom culture. Vygotsky (1978) has also emphasised that culture sets the terms of the dialogue between the child and authority figures which becomes internalised as conscience. This conscience includes the moral values that set standards when producing and using technology in society.

2.2.2 Guided Problem Solving

Vygotsky's great insight was that he realised that everyday interaction between care giver and child had the most profound implications for the development of the child's learning because it was during this interaction that children internalise knowledge and skills from the social to the psychological plane (Kozulin,1990). Long before they enter school, children are learning higher-order cognitive and linguistic skills. Their teaching takes place in the everyday interactions of domestic life. Within these general problem solving activities opportunities are available for more competent members of the household to assist and regulate child performance. In this way children learn the accumulated wisdom and strategic tools of their culture.

From his research Vygotsky realised, however, that the competent other can be an adult or another child, but that his or her actions must be finely tuned with the child's needs in order to assist learning. The kind of finely tuned support that assists children in accomplishing actions that they will later accomplish independently was called by Vygotsky a 'zone of proximal development' (ZPD). This zone is the gap between what children can do independently and what they can do when they are interacting with others who are more competent:

> 'the distance between actual development level as determined by individual problem solving and the level of potential as determined through problem solving under adult guidance or in collaboration with a more capable peer'.
>
> (Vygotsky,1978, p86)

Vygotsky used the Russian term for 'problem solving' but this has been extended to mean performance in other domains of competence (Rogoff and Wertsch,1984). The term 'proximal' (nearby) indicates that the assistance provided goes just slightly beyond the child's current competence, complementing and building upon the child's existing abilities, so supporting or 'scaffolding' learning (Wood, Bruner and Ross,1976). This makes it possible for the child to 'internalise knowledge and convert it into a tool for

conscious control' (ibid). Here the adult acts as a 'vicarious form of consciousness until such a time as the learner is able to master his own consciousness and control' (Bruner, 1986, p123).

Later interpretation of Vygotsky's work emphasises the necessity of diagnosing children's knowledge in order for scaffolding to take place and underlines the fact that, in design and technology learning activities, it is often peers who provide that understanding. Indeed many studies have documented the apparent lack of scaffolding by teachers in the classroom and focused on problems surrounding attempts to scaffold different types of knowledge (Bliss et al, 1994). However, lack of scaffolding in classrooms is often blamed on large classes or social and cultural divides between teachers and pupils. Greenfield (1984) contrasts successful out-of-school problem solving with attempted scaffolding in school, but Bliss (ibid) argues that the two are essentially different in that the knowledge teachers are teaching is counter-intuitive in school. Building the bridge between children's everyday knowledge and some of the very difficult perceptual knowledge that they are required to learn in school is extremely complex. Out-of-school problems may be specific and unchanging, but problem solving in D&T in school entails managing problems in contextually different situations. The interesting thing about D&T problems is that they are a step closer to everyday life than problems in other subject areas; but in D&T there are also some aspects, such as the tackling of certain skills or processes, that are counter-intuitive. This makes scaffolding particularly difficult. Vygotsky himself draws the distinction between home learning and school learning, suggesting that remembering incidents of personal learning from home can aid children in learning at school.

However, as Fischer and Bullock (1984) point out, Vygotsky knew that the learner is not merely a passive recipient of guidance and assistance, and acknowledged the inventive role of the child in transforming what is internalised. Some educationalists have used the term 'guided reinvention', which embraces both social learning and cognitive reconstructivist arguments. This acknowledges the Piagetian insight that to understand is to reconstruct. In design and technology activities it is important that children reorganise and reconstruct their technical experiences, so reinventing strategies in a novel situation or inventing new strategies. In order for their technological capability to progress, they need to begin to see problems from new perspectives or to re-pose or re-create aspects of them completely.

2.2.3 An Interpretation of Vygotsky's ZPD

Vygotsky saw learning as a profoundly social process which needed conversation and mediation. Wertsch (1991) thought that individuals have many ZPDs and that for any competence or skill there is a separate ZPD and there are cultural as well as individual zones. Vygotsky does not offer much in terms of explanation of the ZPD, but Tharp and Gallimore (1993) have taken Vygotsky's basic idea and reinterpreted it in their own terms, and this is useful when attempting to relate Vygotsky's work to the present study. In their notion of assisted learning Tharp and Gallimore (ibid) see four stages of the ZPD:

* Stage 1: Where performance is assisted by more capable others
* Stage 2: Where performance is assisted by self
* Stage 3: Where performance is developed, automised and 'fossilised'
* Stage 4: Where de-automisation leads to recursion back through the ZPD.

According to Tharp and Gallimore, any learner at any age progresses during learning from social regulation to self regulation, but these stages are moment to moment, interrelated, and often merge. The amount of assistance required depends on the age of the learner and the nature of the task. During the infant and early play period children are assisted towards the development of motives for emotional contact, methods of socialising, and situational mastery. Tharp and Gallimore link this to Vygotsky's emphasis on the importance of play. He believed that for children, play was much more practical and down to earth than supposed, and that children used play to create imaginary situations which were very near to reality and in which they sought ownership of objects and control over their environment by the creation of rules for play. He thought that, far from being 'free', it is here that the child exhibits most self control as children's play is self-structured (Newman et al,1993).

The age of role play and early school age, which is that of the present study, is dominated by the development of motives for mastery of the adult world. It also marks the beginning of more formal learning and the development of understanding of related goals, tasks and ways of going about those tasks. Children often need to model or copy the actions of others. Vygotsky himself explains the value of copying for young learners:

> 'The child is able to copy a series of actions which surpass his or her own capabilities, but only within limits. By means of copying, the child is able to perform much better when together and guided by adults, than when left alone, and can do so with understanding and independently'.
>
> (1987, p117)

At this age, say Tharp and Gallimore, children also enter into social negotiation. They are beginning to relate to adult goals and to understand tasks and the means of going about them. They may then begin to negotiate tasks and goals with adults, appreciating that for teachers these often change as the lesson progresses. Saxe et al (1984) maintain that in order to assist learners effectively, and achieve intersubjectivity or full understanding of children's learning needs, teachers often need to shift the goals of the learning task as it proceeds, while keeping the aims of the session constant. It is for this fundamental reason that a profound knowledge of the subject matter is required of teachers who seek to assist performance. In a relatively new subject such as D&T this is especially important, as in order for children to have ownership of the task they need to feel free to negotiate task boundaries with well informed adults or more competent peers.

During the moment-to-moment stages of the scaffolding process, children steadily increase responsibility for their performance, and adult responsibility decreases. This is Bruner's 'handover principle' where the child begins to take control of learning. Wertsch (1979) adds that the activity which allowed the child to participate in problem

solving now allows her/him to carry out the task almost unaided. The final stage of the process marks the internalisation of learning, when the child performs the task automatically without assistance from others. The child has emerged from the ZPD and performs the task smoothly and easily. At this stage assistance can be irritating and often disruptive. Here performance has developed or 'fossilised', emphasising distance from possible social or mental change, and the design and technology teacher needs to be sensitive to the child's need for uninterrupted problem solving. Intervening at the wrong time in the process can be detrimental to learning and task completion. Tharp and Gallimore (ibid) maintain that 'once children have mastered cognitive strategies they are not obliged to rely only on internal mediation'. For example, they can also ask for help when stuck. There is an intimate, shifting variation between control by self and control by others.

In the scaffolding process for children, there is a recurrent cycle of talking to self or self-assistance and other-assistance. This is also true for adult problem solving, as not only automatic performance occurs but de-automatisation and recursion because change in context, stress, or forgetfulness, present the need to relearn cognitive strategies. As adults get older the need to talk to oneself recurs, and it is the first retreat in times of great difficulty or very knotty problems. In this way cognitive strategies may be perceived to decline or recur, not only during the moment-to-moment problem solving task, but in the pattern of learning throughout life.

Tharp and Gallimore make a worthy attempt to describe what they term as 'assisted learning', inspired by Vygotsky's work. Vygotsky does not offer much in terms of description of the ZPD, and they have created a useful version of his ideas. However, Tharp and Gallimore's suggestions are purely interpretation, and it is debatable whether Vygotsky would explain the process through the zone of proximal development in these terms. The word 'stage' here may be misleading as the process is seen as moment-to-moment interaction. The length of these stages may differ according to age but Vygotsky's analogy between microgenesis and ontogenesis is not clearly linked in this work. These phases may represent the process of problem solving through the use of cognitive strategies during any one task, but may they also represent the process of development in social and self-regulation in learning from child to adult? It is not clear. Tharp and Gallimore state:

> 'Developmental processes arising from assisted performance in the ZPD
> can be observed not only in the ontogenisis of the individual but in
> the microgenesis of discrete skills as they develop throughout the life course...'
>
> (ibid, p47)

Did Vygotsky see the collaborative learning of human beings throughout life mirrored in the moment-to-moment problem solving process?

2.2.4 Tools and Symbols

The third main theme in Vygotsky's writing was his ideas about tools and symbols. So far, it has been suggested that for Vygotsky learning was a constant transformation

throughout life; a continual inner revolution where ideas and strategies emerged through learning, changed, declined and were replaced or relearnt. Moll (1993) argues that just as Marx wrote that the use of physical tools revolutionised social relations, so Vygotsky used the notion of 'psychological tools' to explain the developmental revolution from 'natural' to higher mental processes. Luria's research involved close observation of how Russian peasants used tools in their work and how manual skills helped develop their thinking skills. In this way children's problem solving strategies may be acquired through the use of physical design and technology tools, so that psychological tools may be acquired through technical tools.

A similar theme is also found in Luria's historical approach. In their classic work *Ape, Primitive Man and Child* (1930), Vygotsky and Luria saw the invention of implements by animals as crowning their development. In primitive man the use of speech fulfilled this function, and in the child the cultural origins of behaviour. The tools or implements of the ape were analogous to the psychological tools of speech and cultural interaction in humans. Vygotsky wrote:

> 'Mastery of tools is a sign of high psychological development; and we may safely assume that the processes leading to mastery of the tools of the external world, and to the unique elaboration of internal psychological devices, together with the ability to make functional use of one's own behaviour, are all characteristic elements of the cultural development of the child's psyche.'
>
> (ibid, p117)

Vygotsky (1987) distinguishes between real and technical tools, psychological tools, and systems as tools. He mentions not only spoken language but systems of notation, diagrams, maps and drawings. In this way plans and diagrams, or models created in D&T sessions in school may be seen as tools, and in the technological world outside school it is these signs and symbols that are the tools of communication. Baynes (1992) suggests that the modelling methods available to designers directly affect the thoughts they can think, and Kimbell et al (1996) state that the language of technology is indisputably a concrete one of images, symbols and models. It will be interesting in the present study to explore how far children use that language as a technological development tool.

So far two main types of tools have been mentioned: technical and psychological tools. In their book on Vygotsky's work Newman and Holzman (1995) take some care to point out the essential difference between the two, but they go further in recognising a third type of tool in Vygotskian theory. First they distinguish between technical and physical tools such as the hammer or saw, and psychological tools or producers of concepts, beliefs, ideas, thoughts and language, calling these 'tools for results'. They then draw the distinction between 'tools for results' and 'tools and results'. 'Tools and results' refers to both physical and psychological tools, but used to affect their users as a society. For example, human evolution is altered by man-made tools, so man changes himself and his culture; and language, used first as a communicative tool, finally shapes

the minds of those who adapt to its use. So as Bruner (1987) points out, the tools and devices humans employ finally shape them. Newman argues that Vygotsky rejects the notion of 'tool for result' in favour of 'tool and result' but this appears too exclusive. Rather, there seem to be three types of tools in Vygotskian theory: the technical tool, the psychological tool, and the 'tool and change'. This last idea is important for design and technology education in that it places the use of tools, and their function in problem solving, at the centre of cultural and historical as well as technical change. But it presents a deterministic view of Vygotsky's work in general and represents a passive view of the child, very much in the hands of the more competent other. In reality children can be autonomous learners and do not always need to wait to be scaffolded by a peer or adult in order to internalise knowledge. Bruner seems to have gone too far here.

However, Vygotsky's ideas are complex and difficult to interpret, especially since in translation from Russian, the meaning of certain words is not always clear. Educationalists have sometimes extended the specific to the general. For example, problem solving has been taken to mean learning in general, and scientific thinking taken for school-like thinking. Vygotsky himself has been criticised for basing his ideas on the research of others, which was not highly controlled and used mainly illiterate peasants, children and the mentally ill. Kozulin (1990) suggests that children were viewed by Vygotsky as primitive thinkers within a hierarchy of development, and that he believed young children learn by remembering and that only adults' memory supports logical problem solving. Kozulin (ibid) believed that children's peer culture was seen by Vygotsky as different, like that of peasant culture, but not valued except as a step towards cultural historical change. Despite this, it remains true that Vygotsky made a unique contribution to the understanding of human cognition by his interest in psychological tools and his insistence that society rather than the individual is the origin of mental functioning.

2.3 Peer Collaboration

Vygotsky suggested that peers can be important in learning since a more capable peer might scaffold intuitively in collaborative activities, and Piaget highlighted the crucial role in learning of the relationship between individuals in peer interactions involving cooperation and conflict. But the work of researchers such as Doise and Mugny in the early 1970s, Perret-Clemont (1980) and Light (1983) has contributed greatly to our understanding of social cognition arising from peer interaction. Such peer collaboration is an important feature of design and technology in primary schools. Therefore, it is essential that this work, together with a consideration of more recent work in this area (Kutnick, 1990; Galton,1992,1999), be part of the theoretical background to the present study.

2.3.1 Doise and Mugny, and Socio-Cognitive Conflict

The formative work of Doise and Mugny is based on a so called 'socio-cognitive conflict' view of collaborative learning where learners are confronted with new or conflicting ideas. Doise and Mugny (1984) argue that social interaction itself gives rise to

the formation of new cognitive structures within the individual. Most of their work stems from Piaget's book 'The Moral Judgment of the Child' (1932) and they take a Neo-Piagetian stance, perceiving cognitive conflict as the catalyst for developmental change. Studies by Doise and Mugny (1979,1984) have looked at the relationship between social interaction and performance in various cognitive domains, such as spatial and mathematical problem solving. They stress the usefulness of specific collaborative and cooperative grouping of children to promote the transition from one Piagetian stage to the next. This approach has focused particularly on young children's transition from pre-operations to concrete operations, through cognitive conflict between equal or mutual peers when they attempt to solve a common conservation problem.

It is most important to stress that the word 'conflict' here is misleading. Behaviours that can be described as cognitive conflict can range from a peaceful turn-taking discussion to forceful arguments. Building on the work of Doise and Mugny, Kutnick (ibid) maintains that forms of cognitive conflict may be generated only in mutual, non-hierarchical, participatory, learning situations. Piaget himself asserted that 'criticism is born of discussion and discussion is only possible amongst equals' (1932, p 450), and Bryant's research (1984) suggests that often it is not conflict which leads to enhanced cognitive performance but agreement.

However, Doise and Mugny maintain that most children working together in small groups experience more stimulation, construct more effective argument skills, devise more effective coping strategies, and subsequently perform better than children working individually. Their work explores the precise nature of the conflict that occurs when children encounter an idea which diverges from their own. Mugny et al (1984) talk of 'cognitive restructuring', and Light (1983, p326) explains that this means that alternative cognitive models, derived from interaction with other children, 'suggest to a child some relevant dimensions for a progressive elaboration of a cognitive mechanism new to him'. Moreover, Doise and Mugny (1985) have argued that the cognitive progress of a child is enhanced where the social-cognitive conflict is intensified. The research here involved comparing learning situations where three children working in a group included one or two 'disagreers'. The results indicated that children who found that they had to argue with two rather than one of their peers in order to defend their ideas, subsequently performed better during post-tests, implicating the role of perspective taking. Craig and Washington (1986) have found that children often find the demands of three-party conversations quite unique and need to develop more complex strategies to deal with this situation. Perhaps it is the challenge in developing these strategies that increases performance and enhances cognition.

Recently, Doise (1990) has adopted a more socio-constructivist view of children's collaboration. Here, Doise reflects on his previous investigations which showed that developmentally more advanced responses in children appeared in collective situations *before* individuals were capable of them. Doise states:

> ' It is above all, through interacting with others, coordinating his/her approaches to reality with others, that the individual masters new approaches. The individual

> child masters schemas, behavioural repertoires, and motives which 'enable' participation in social interaction...These new competencies then allow the individual to benefit from more complex social regulations and so on.'
>
> (Doise, 1990, p46)

Doise talks of a 'spiral of causality', beginning with the mental state of the child, which makes possible engagement in social interactions and new cognitive operations, because these interactions in turn qualitatively enrich the emergent new individual states and facilitate progress.

Doise then goes further to put a moral position for greater attention to collaborative cognition, calling for a socio-constructivist theory of communicative behaviour and ethics. He argues that we need to understand social role 'scripts', which govern the social interactions in which the child may participate, in order to provide the child with models of both cognitive functioning and moral reasoning. He cites the work of Kohlberg (1981) on young children's moral dilemmas, and argues:

> 'As a citizen it is not possible for modern man to act without models of idealised situations...After all, once modern man has dismissed supernatural and imposed authorities, the only way for him to reach each truth and justice is to construct them through social interaction.'
>
> (Doise 1990, p 61)

Doise and Mugny have been criticised for their overemphasis on the role of conflict in collaborative learning (Forrester, 1992) but, as we have seen, the word 'conflict' can be misinterpreted and can be used in discussing many different types of collaborative situations. Most importantly, the research of Doise and Mugny demonstrated that learning can take place through the very process of conflict, and subsequent research building on their work (Swan, 1992), has shown that conflict between ideas can lead to progress whether or not there is a correct answer to the problem to be solved. In many tasks in school there is no correct solution, especially open-ended tasks in design and technology lessons, but working with peers gives children the opportunity to take joint responsibility for design outcomes and technological products, heightens awareness of value judgments about our role in the world, and can encourage citizenship.

2.3.2 Perret-Clemont and Social Marking

A rather different explanation of how learning takes place during collaboration was proffered more recently by Perret-Clemont and Light (1989). Perret-Clemont worked with Doise and Mugny in Geneva in the 1970s, when they first embarked on their research into the role of peer interaction in cognitive development. Together they formed a view of collaborative learning that resulted from socio-cognitive conflict (Doise, Mugny and Perret-Clemont,1975). This work concentrated on identifying conditions under which cognitive changes occurred, with a particular emphasis on the different combinations of

cognitive levels and different roles of individuals in the group. But despite this strong focus there were indications from the start that responses to the investigations were influenced by wider socio-cultural factors (Mackie,1980; Perret-Clemont, 1980).

Perret-Clemont observed that working class children tended to perform significantly less well than middle class children in conservation post-tests, and then began to notice other contextual factors contributing to peer interaction in stimulating the right responses. For example, there was evidence that setting conservation tasks within the context of a competitive game, with specific reference to the need for 'fairness' and establishing equal shares of juice, led to significantly better results in conservation tests. Perret-Clemont pointed to the fact that the efficacy of peer interaction procedures may arise, not only from socio-cognitive conflict, but from the notion of sharing and equality. This interpretive shift introduced the concept of 'social marking'. Light and Perret-Clemont, (1989, p145) refer to the process of social marking as:

> '...the way in which the ease or difficulty of a cognitive task can be affected by the extent to which it can be mapped onto social norms or rules with which the child is familiar'.

From then on the importance of the social norm, or rule of equality for children during problem solving tasks, became increasingly apparent (Girotto, 1987; Doise, 1985). But Nicolet and Iannaconne (1988) found that the norm of fairness depended very much on the level of competitiveness or cooperation existing previously in the group. It was also found that social marking as a mechanism did not depend on the actual presence of others, but could be effective if the children were asked by an adult to give equal shares to 'children who would come in a minute' (Doise, ibid). In this way, socio-cognitive conflict requires the presence of other children in the group but social marking does not.

2.3.3 Understanding Conflict and Competition

The work of Perret-Clemont and Doise and Mugny goes beyond the understanding of children's ideas about conservation to tell us about the origins of that understanding. They point to the socio-cultural creation of that understanding and provide a view of the child as:

> 'an apprentice to his or her own culture... inducted into socially supported correct performances, which bridge from the familiar to the unfamiliar, from the known to the unknown'.
>
> (Perret-Clemont and Light, ibid, p147)

The importance of the social context or boundaries of problem solving tasks, and the rules and norms that create those boundaries, is demonstrated in the work of these theorists.

Today our concern is less in terms of socio-cognitive conflict or social marking,

when we think about young children's collaboration, and more in the fact that interacting with others transforms the learning experience for children. Edwards and Mercer (1987) talk of collaboration between children to create 'common knowledge', as the understanding created and shared by children through their interactions. Consequently in their view learning is essentially collaborative, developing through children sharing problems together. They suggest that through discussing, negotiating and pooling experience, a new level of understanding is achieved, and that conflict of ideas may not be necessary. Nevertheless, an understanding of the place of conflict and competition in collaboration is worthwhile as it may be an essential dynamic in collaborative learning.

Pondy (1972) makes a distinction between two types of conflict amongst young children working in groups. The first is an intellectual conflict of ideas, 'perceived conflict', and the second an emotional or 'felt conflict', with a greater effect on a child's sense of self. For Pondy an understanding of these two types is important as it explains the 'personalisation of conflict' (p 362). Sometimes a conflict of ideas can easily become an emotional conflict, especially in open-ended problem solving, and children may need to negotiate ways forward, or a clearer specification of the task. But this negotiation will be influenced by the allocation of power and control within the group, often creating competition. Fogal (1993) maintains that if personal or intellectual power appears to be distributed unevenly within the group then the likelihood of competition is high, and successful collaboration low. Also, Hayes (1991), reporting a study of collaborative problem solving by primary pupils, commented that once a hierarchy or dominance was established, then performance of the whole group was constrained by this social ordering. Without strategies to deal with dominance, then disruption or withdrawal may be the only alternative for some children, while others may thrive personally on competition. Building on Pondy's work, Biott and Easen (1994) suggest that any kind of collaboration in groups is essentially about children developing strategies to handle two types of conflict:

*Intellectual conflict: children need to develop strategies for asking questions and analysing possibilities, rather than tactics of assertion and counter assertion.

*Emotional conflict: children need to develop the type of strategies often associated with counselling, such as acknowledgement, according personal respect and active listening, rather than using tactics that block or reject their peers.

This sort of understanding about conflict in collaboration helps to explain the significance of a typology of helping strategies identified by Burden et al (1988). In their study of primary children's collaborative group work in mathematics, more successful groups used types of helping strategies such as: organising, supporting, challenging, suggesting alternatives and explaining. Help giving and help seeking strategies are complex interactions. Many studies on children's group problem solving have recognised that contextual and personal factors have made collaboration difficult, and the personal,

social and cognitive risks can be high. However, both intellectual and emotional conflict need to be recognised as integral parts of collaborative relationships, and the strategies that children use to cope with them explored. Research suggests that on entering school young children judge their own success more in terms of social competence than academic ability. They see themselves as successful if they have good friendship groups (Sylva, 1993). Generally, evidence indicates that children *need* peer interaction in order to develop adequate social cognitive skills and achieve social competence (Perret-Clemont, 1980).

2.3.4 Galton's Research on Collaboration

Despite the fact that research shows that potentially children learn best in interaction with peers, observation studies of group work in primary classrooms have found that this potential is seldom realised (Bennett et al, 1984; Galton, 1992). Galton's ORACLE study (1980) was the first large study of primary classrooms in Britain to use systematic classroom observations to examine teacher and pupil behaviour. One major finding contradicted the widely held belief that primary children spend a great deal of time working in groups. Although they were seated in groups, very little collaborative work was observed, and grouping seemed to be used by teachers as an organisation strategy rather than a device for encouraging more effective learning. Sixty per cent of teachers in the sample never used collaborative group work in art, craft or technology lessons, and 'only ten per cent of all the work observed across the curriculum was cooperative, some children never experiencing it at all' (ibid, p71).

Galton's (1992) research began with a small project that grew out of the ORACLE work. Galton describes his experiences as he spent a term working alongside two teachers with very different group work styles. One teacher encouraged group work where pupils had the same task but produced independent products, and the other where pupils worked together on one joint product. His insightful descriptions, supplemented by ample reference to recent studies in America and Israel, looked at children's group work strategies. Two important and often neglected aspects of his work deserve to be mentioned here. Firstly, he found that the pupils' perception of the teacher's intention was crucial. No matter how much the teacher herself de-emphasised 'getting the right answer', the pupils themselves saw this as the main purpose of the learning task. They tended to see the task as one of producing an end product and disregarded the problem solving process. They needed to be helped to appreciate the value of group discussion, deliberation, and sharing and listening skills. Secondly, some pupils were reluctant to take part in group work because of lack of confidence and self-esteem. The aims and objectives of learning tasks needed to be clear at the outset.

The recent follow-up research to the ORACLE study (Galton et al, 1999) was done in 1996-97 in 38 primary schools, most of which had featured in the earlier study. It found that both group work and class teaching has doubled during that time. However, what teachers do during this time remains much the same. Galton says that the shift to class teaching means that teachers spend much of their time talking *at* children rather

than with them. Furthermore only ten per cent of questions were cognitively challenging. What has changed is the nature of group work. Pupil interaction has increased from 19 to 27 per cent, and while much of the interaction was not task related twenty years ago, this is no longer the case. However, the growth of class teaching has encouraged what Galton describes as 'easy riding' in both whole class lessons and group work. Children are quietly opting out of the learning process, and maximum peer interaction and stimulation is avoided.

Galton's long standing research in this area (1980,1992,1999) suggests that in order to counter this, children should be taught the attitudes and skills needed to sustain effective learning through collaboration. Typically told to work quietly, alone and at speed, Galton suggests that they find it hard to accept that talking, arguing and discussing in groups are acceptable in class. He feels that the 'ground rules' for acceptable behaviour in groups and the processes involved need to be made explicit to children. Discussion about the nature and effectiveness of group problem solving can help them to appreciate the intended goals, procedures and communication practices involved.

2.3.5 Aspects of Gender with Reference to Goffman

It can be seen that effective collaboration by children in the classroom depends on teachers valuing group work, but also making collaborative strategies explicit to groups in order to heighten their awareness of each other's roles in the learning process. But many other factors, such as the make-up of the group in terms of ability, culture and gender, also have a great impact on children's collaboration (Wood,1998). Although the present study is not directly focused on gender issues, aspects of gender relationships materialise from the research.

It is well documented that from an early age, well before they come to school, children are socialised into gender roles and begin to identify social roles in terms of gender (Leaper,1995; Martin,1993), and design and technology as a curriculum area seems to accentuate this (Ross, 1993; Browne,1992). At Key Stage 1, research indicates that girls and boys view D&T role play activities in a different way and make different types of decisions when choosing resources for designing and making. For example, from interviews with five and six year olds it emerged that many design and make activities engaged in by girls were dominated by rules, while many boys' chosen problem solving activities were open-ended, such as laying a train track, or working with cars or bricks. Ross (1993) found that when an activity was preferred by girls or boys, over time it seemed to affect the children's entitlement to the activity and became either a boys' or a girls' activity in the children's eyes. Such activities included designing and making cardboard doll houses or sewing dolls' clothes for girls, and construction or making toy guns for boys. Somehow, metamessages (Bateson,1972) travelled between the children conveying that certain problem solving situations were the domain of either girls or boys, and this affected their respective confidence, skill and willingness to engage in them.

Another way to think about metamessages is that they frame a situation, much as a picture frame provides a context for the images in the picture. Metamessages allow for

interpretation of what is being said or done beyond the obvious. At the same time they let it be known what position individuals are being assigned. The sociologist Goffman (1974) used the term 'alignment' to express this aspect of framing. For example, if an individual within a group talks to others as if to 'put them down', they are taking a superior alignment as a teacher or parent. This conveys the message that others are perceived as incompetent or naive. By talking or acting in certain ways, both girls and boys send metamessages about suitable design and technology activities according to gender, and stand together in alignment in contrast to each other. Girls and boys engaged in design and technology, even at an early age, 'frame each other by metamessages of control' (Goffman, ibid). They may adopt a protective, gallant, decisive or dominant frame, but they send these messages both by speech and gesture.

Goffman's work regarding gesture includes innovative research on body language as a means of conveying metamessages about the meaning of interaction. In his formative book 'The Presentation of Self in Everyday Life' (1959), he focused on the way in which individuals convey an impression of self to others in 'the minute system of face to face interaction' (ibid). Goffman (1959,1981) created a framework for thinking about self presentation through social action, and even in his early work acknowledged that gender display was embedded in self presentation (1979). Gender is a category that, without our knowing it, pervades all interactions. As Goffman (ibid) put it, it is 'one of the most deeply seated of mans' traits' (!) Even as young children, we create masculinity and femininity in our ways of behaving, all the time believing we are acting naturally, but what we regard as natural is different for boys and girls and is based on asymmetrical alignments. Leaper's (1995) research documented how five year old girls elaborate on each other's ideas in a 'mutually positive' manner, whereas boys of the same age exhibit 'negative reciprocity', whereby one boy tries to control while the other withdraws.

Not surprisingly, Corsaro and Rizzo (1990) studied American and Italian five year olds and found that boys were most likely to set up conflict situations while creating role play scenarios, but this facilitated rather than prevented constructive play. Girls, on the other hand, were concerned to agree in designing family based role play situations. Other studies (Murphy,1992; Randall,1987) support the findings that young girls' self structured play tends to be about community, while boys tends to revolve around conflict. When asked to design and make boats, seven year old boys detailed weaponry and mechanisms for movement and navigation, while girls focused on the living conditions of cruisers, including food supply. Similarly, when designing and making vehicles, boys chose army and 'secret agent' type vehicles while girls chose family cars and babies' prams. It is interesting to mention that Johnston (1989) found that adult stories created and told by men relate human contests, such as fights and conflicts concerned with hunting and fishing, where the protagonist is always male; while narrative created by women revolves around joint action by groups of people helping each other out of problems, or about peculiar people dramatising their abnormal behaviour and setting it against social norms, and where the characters are both male and female.

Even in his earliest work, Goffman saw that self presentation represented the values of the community at large. He said:

> 'When an individual presents himself before others, his performance will tend to incorporate and exemplify the officially accredited values of the society...(it will be) an expressive rejuvenation and reaffirmation of the moral values of the community.'
>
> (Goffman, 1959, p31)

Gender differences are often reinforced by teachers. White (1989) studied what she called the 'relentless politeness' of primary school teachers. She noticed that in using 'polite' ways of speaking, such as always praising good behaviour rather than censoring bad, primary teachers were directly praising girls and ignoring boys. Boys' speech patterns and behaviour were generally characterised by action and authority flouting, while girls were generally more passive and compliant. Boys' conversations tended to revolve around joke telling and rule breaking, while girls' talk contained matching domestic complaints and exchange of mutual support.

Kimbell's research in primary schools (1996) provides evidence that in general, girls are better able to get to grips with D&T tasks when they see them in a 'people-rich context'. They are automatically accommodating, whereas boys have an ability to grapple with technical constraints and are automatically independent. Tannan (1992) suggests that both boys and girls could benefit from learning each other's styles. Many girls could learn from boys to accept conflict without always perceiving it as a threat, and many boys could learn from girls to accept interdependence without seeing it as intimidation. Perhaps, the best style to encourage in school is a flexible one. Through self-awareness, it is possible to choose which strategies to use despite gender styles. Gender aspects were embedded in only a small part of Goffman's work. He was remarkable in that he revealed the meaning of ordinary behavioural aspects of our daily lives. He showed us that by becoming aware of our automatic performance it is possible to adapt our habitual styles when they are not serving us well.

2.4 Rogoff, Lave and Situated Cognition

Vygotsky's work on the zone of proximal development has been extended by Rogoff (1990) in her idea of the child as apprentice. However, a less passive view of the child as problem solver, engaged in activities which present authentic dilemmas, exists in the work of Lave (1992). This situated cognition stance offers a view of cognitive processes that differs according to the domain of thinking and the specifics of the task and context. It values the intimate connection between knowing and doing and views learning as a process of enculturation through shared activities into a community of practice (Wenger,1991). This literature seems appropriate to learning in design and technology as it focuses on three essential aspects of the activity. It centres on how the context of a task affects children's strategies during problem solving, on how children

might be inducted into a process such as design, which draws upon industrial and cultural models, and on how the content of knowledge, skills and understanding of technological activity is introduced to children.

2.4.1 Rogoff and Apprenticeship

Rogoff's (1990) research into the processes of 'everyday' or 'situated' cognition is heavily influenced by the work of Vygotsky (1978). Rogoff's investigations show that the learner or child can be likened to a novice, guided by a more able adult as he or she builds a framework of understanding. Rogoff extends Vygotsky's notion of the ZPD, as she views children as apprentices whose learning is facilitated through a series of cognitive processes such as modelling, coaching, scaffolding, fading, articulation and reflection on their own problem solving strategies (Collins, Brown and Newman,1989). This apprenticeship entails the adult providing support by posing alternative viewpoints to the problem through articulation and argumentation, and by making explicit their knowledge through modelling effective strategies, and demonstrating ways of problem solving in authentic activities. It continues through coaching, or the social sharing of tasks and solutions, and scaffolding, or cueing and building links with other knowledge. This allows the gradual development of skills and understanding. Fading then involves the slow withdrawal of help as the apprentice becomes more competent, and independent thinking and practical skills are developed. The ultimate aim is to give the learner or apprentice control over their own learning processes and the confidence to engage in critical analysis of the problem and alternative solutions.

2.4.2 The Importance of Intersubjectivity

Rogoff and Gardner (1984) stress the importance of intersubjectivity, or close understanding between the child and adult. They were working from information gained from their observations of adults instructing children aged six to nine years when they proposed that guided participation involves the following activities:

* Providing a bridge between familiar skills and those needed to a solve new problem
* Arranging and structuring problem solving
* Gradually transferring the responsibility for managing problem solving to the child.

When building effective problem solving strategies they considered it essential that the tutor understands and displays sensitivity to the learner's current needs. Rogoff calls this closeness the 'intersubjectivity between the child and the adult'. This involves a sensitive adjustment in levels of instruction. The tutor must be aware of the knowledge base and performance characteristics of the child, and have an appreciation of the skills and knowledge needed to tackle the problem independently. Wood, Bruner and Ross (1976) maintain that problem solving has a deep structure and it is sometimes difficult for the tutor to understand the hypothesis of the learner at the beginning of the process. Often it is not until well into the activity that the learner's ideas for a solution can be

understood, and tutors cannot always be sure whether a child is systematically ignoring a suggestion or misunderstanding it. The learner must begin to tackle the problem before the adult can intervene. This intervention must be modified according to the child's responses, so that there is a subtle diagnosis, intervention or cueing, observation of the learner's response, and re-evaluation of the learner's level.

2.4.3 A Process of Socialisation

Rogoff's work in this area discusses the aspects of guided participation in which the adult and child work together to provide the sensitive adjustments in levels of instruction, praise and support, needed to build effective problem solving strategies. Rogoff (1986) proposed that 'guided participation with school children involves adults leading children through the process of problem solving'. Hennessy (1993), in the background to her study of secondary children's D&T problem solving, describes this as a process of socialisation, through guided participation in relevant problem solving activities, in which adults support children in learning the social and cognitive skills and values important in their culture.

Rogoff (ibid) calls this the 'gradual immersion of children into the skills and beliefs of their society'. She offers examples of mothers intentionally teaching their children about social rules and expectations, and consciously adjusting their input and demands to the response of the child. She stresses the importance of achieving a shared focus of attention with children's participation and social guidance, building on both the child's and the adult's perspective. Support in these contexts offers both challenge and sensitive assistance to the child, but lack of familiarity with the child's background leads to difficulties for both the apprentice and the tutor. Successful guidance is based on shared culture and social understanding.

In this way situated cognition considerably widens our view of cognition during problem solving 'to recognise the critical role of the social and physical in circumstances in which actions are situated' (Suchman,1987). It views thinking as part of a culturally organised activity in which specialised local knowledge, norms, practices and vocabulary are developed. This uses the links previously made between Vygotsky's work and design and technology education because the child may be viewed as apprentice within a culturally organised community of practice, being inducted into specialised skills, local knowledge and technical vocabulary. However, this presents a view of the active adult and a more passive child in the problem solving process.

2.4.4 Rogoff and the Active Adult

There are certain drawbacks in accepting, without question, Rogoff's apprenticeship model as a theoretical frame for the present study. Rogoff's ideas concerning the processes of 'everyday' or 'situated' cognition are based on her view of the active adult who is constantly resourceful in devising clues or links for children in order to support and extend their learning. Rogoff's research documents how the adult works to understand the child's perspective and previous knowledge, and to become familiar

with the child's cultural and social background, towards maximum intersubjectivity. When writing about the process of guiding young children, Rogoff (1989) states:

> 'Adults arrange the occurrence of children's activities and facilitate learning by regulating the difficulty of the tasks and by modelling mature performance.'
>
> (Rogoff, 1989, p69)

A picture emerges of the enterprising and industrious adult, but also of the more passive apprentice who is caught in an induction mode of learning, able to make less effort to facilitate the learning process than the expert. Here the adult may be viewed as the one who is proactive in constructing intervention strategies to facilitate the learner's progress. It is also the adult who is seen as enabling problem solving strategies to be devised by the child by passing on technological skills, processes and traditions, and scaffolding the child towards already established problem solving strategies. Rogoff begins a key article by quoting Newman (1982):

> 'The young child is often thought of as a little scientist exploring the world and discovering the principles of its operation. We often forget that while the scientist is working on the border of human knowledge and finding out things that nobody yet knows, the child is finding out precisely what everybody knows.'
>
> (Newman, 1982, p26)

This presumes only one way of knowing and that we always know what children understand. It also assumes little room for pupil autonomy. To be fair, Rogoff and Gardner (1984) admit that while adults play an important role, this role is meshed with the efforts of children to learn and develop, but the nature of these efforts is not fully explained and tends to present a picture of reliance on adults. In reality, young children are often independent learners who devise strategies for learning which involve them in challenging situations.

It could be argued that this image of the child in Rogoff's apprenticeship model may be countered by her inclusion of the 'more competent other' in her ideas about scaffolding. Rogoff maintains that an adult or more competent other may scaffold the apprentice towards problem solving. In this phrase she includes peers or other children. Although this does not alter the status of the individual apprentice, it passes some control to children in that each child may on occasion act as expert within certain contexts depending on their level of knowledge and skills.

Despite this, Rogoff has until very recently paid little attention in her writing to peer scaffolding (Rogoff, Radziszewska, and Masiello,1998; Rogoff et al, 1995) She has underplayed the way children quite naturally imitate and learn from peers but her work in recent years demonstrates a growing interest in the construction of creative strategies by peers (Rogoff, ibid,1998). Before this, in the context of technological activities, guided participation with peers was seen as not so successful as with adults, particularly when this

involves future events, for example planning a design. McCormick et al (1994) maintain that this is due to children's need for a skilled partner such as an adult to 'spell out' the process. It is well documented elsewhere, however, that collaborative peer experiences challenge children to master new cognitive and social skills (Hartup, 1992; Selman and Schultz,1990), and that the intervention of an adult may destroy rather than support this process (Griffiths, 1983; Wood, 1998).

However, Rogoff's (1998) most recent writing focuses on how seven year olds are proactive in devising flexible goal oriented strategies to develop creative planning during collaborative role play situations. Rogoff et al, examine how social organisation is essential to the process of planning, as a group of young children plan a play. The researchers follow the germs of the children's ideas as they are offered, critiqued and elaborated by each other, and consider the role of the classroom structure, teacher support, and fairy tale script as tradition, in this event. But Rogoff is at pains to stress the dynamic sociocultural nature of creative planning in relation to the children's cognitive processes. She says:

> 'Whereas many traditional perspectives view creativity and planning as cognitive products, mental possessions or individual traits, our purpose has been to explicate sociocultural processes in children's collaborative creative planning. We emphasise both the process and the sociocultural nature of planning and argue that in order to plan collaboratively children need to develop ways of managing both social relations and the cognitive problems inherent in the project.
>
> (Rogoff et al, 1998, p 255)

The sociocultural nature of design and technology focuses on collaborative teamwork and empathising with the needs of users through creativity and invention. It requires communicating via joint speculation, visualisation, planning and modelling, to evaluate potential solutions to realistic requirements within specific cultural contexts. To parallel Rogoff's argument, young children need to devise strategies and develop ways of managing both social relations and the cognitive problems inherent in D&T tasks. For, as she maintains:

> 'Regardless of whether we investigate artistic, scientific or everyday planning, these all take place within sociocultural communities. The individuals contribution to creative planning is only a part of a broader dynamic sociocultural process, in which the whole is greater than the sum of the parts.'
>
> (Rogoff et al, 1998, p 256)

Rogoff is beginning to explore how guided participation would work during peer scaffolding, and so far has concentrated on the active adult structuring the child's

learning. But although Rogoff's research is beginning to involve work looking at how groups of young children interact, it is the work of Lave et al (1992) within the theory of situated cognition that redresses the balance to focus more productively on the active role of the apprentice or child within the problem solving process.

2.4.5 Lave and the Active Apprentice

A less passive view of the apprentice as problem solver, engaged in activities which present authentic dilemmas, exists in the work of Lave (1992). Within a situated cognition stance she also offers a view of cognitive processes that differs according to the domain of thinking and the specifics of the task and context, but she values the intimate connection between knowing and doing that enables the apprentice to utilise scaffolding productively. Perhaps even more than Rogoff, Lave views learning as a process of enculturation through shared activities into a community of practice as she concentrates on the importance of presenting children in school with real problems to solve, drawing on their everyday knowledge or their 'knowledge in action' (Wenger,1991).

But the credit for the notion of 'knowledge in action' should go to Giddens (1984) who argued that knowledge-in-practice, constituted in everyday settings, is the locus of the most powerful capability. Just as Giddens attempted to form a general theory of society and bridge the gap between action and social structure (Thompson,1989), so Lave tried to develop a model of social action in the everyday world towards a theory of cognition. She based this on Giddens' key notions of *agency* and *structures.*

Giddens (ibid) perceives society to be constituted by the actions of individuals, and because of this, he acknowledges the role of *agency* in social change. His model of the knowledgeable actor assumes that individuals maintain changing degrees of awareness about the motives for, and consequences of, their actions. Rather than a perception of the conscious and the unconscious, this model distinguishes between *discursive* and *practical consciousness* and three levels of motivation (Giddens,1984). Unconscious motivations are shown to be a significant aspect of social action; however, greater focus is placed on *'practical consciousness'.* Giddens defines his *discursive consciousness* as the level at which actors are aware of the reasons behind their action. *Practical consciousness* is defined as the ability to act without necessarily being able to account for that behaviour. Tradition, habit and routine may be included in this level and it is this level of consciousness which sociologists are most concerned to study. Giddens illustrates that there is a large amount of mobility between the practical and discursive levels. This model allows for the ability of actors to increase their own awareness of the motivations for their actions. In this model the boundaries of discursive and practical knowledge should be assumed to be constantly changing.

Giddens (1979) believes in strategic action. He feels that individuals are continually involved in the reflexive monitoring and rationalisation of their actions. The monitoring of action occurs at an individual and social level as actors monitor their own behaviour and expect others to do the same. Rationalisation also occurs generally in a routinised form to maintain a 'theoretical understanding' for the grounds of action.

Especially in his later work, Giddens speaks of the 'analysis of strategic conduct', which he sees as the power of *agency* or practical action. *Agency* is seen by Giddens (1984) as the ability to deploy causal powers. He also states that 'action depends on the capability to cause a difference', and that an individual is considered to have lost his or her agency if he or she is 'unable to exercise some form of power' (ibid). However, Giddens also believes that unintended conditions and consequences of action feed back into motivation.

Lave was inspired by, and borrowed, these ideas. In the introduction to her book, 'Cognition in Practice' (1988), Lave hints at the debt she owes to Giddens. She says: 'Theoretical syntheses, such as Giddens (1979:1984) argue that integrating social action and social structure is the key problem' (1988, p13). But she also cites Giddens' work extensively in the appendix notes (ibid, pp191-204). Lave's book draws on a number of key studies done by various researchers characterising practical strategic action in everyday situations. These work situations span several cultures and document the technological or craft apprenticeship of tailors in Liberia, pottery makers, street vendors in Brazil, and supermarket shopping, cooking and dieting in the West. The work shows how problem solving is dealt with inventively and effectively in everyday situations, often without recourse to the methods taught in school. Lave demonstrates how personal and collaborative problem solving strategies are devised and used successfully by adults in practical situations. This work is supported by similar studies of children selling produce in Brazil (Carraher et al, 1987) and dairy employees (Scribner, 1985).

In addition to *agency* the other of Giddens' key ideas is that of *structures*. In their most general sense, structures are defined by Giddens as *rules and resources*. The term *rule* is problematic, but is generally defined by Giddens (1976) as sets of norms and principles which individuals follow that may be part of the practical consciousness. *Resources* are divided by Giddens into allocative and material resources. These are shared by actors in the same society and therefore action is socially determined in nature. For this reason Giddens suggests that actors should be perceived as groups rather than at the individual level. *Structures* are described as 'the medium and outcome of the practices they recursively organise' (Giddens,1984). Although structures are often beyond the direct control of agents, they are seen to be both enabling and constraining in structuration theory. Unlike the Durkheimian sense of rule structure, according to Giddens, they not only coerce the individual into a course of action but also allow the individual to extend his choices.

Following Giddens, Lave (1977) argues that 'problem solving strategies are shaped by the structuring resources available in the situation.' The apprentices were found to invent strategies that were based on the physical resources available to them. For example, in order to solve problems of calculation and transportation, building workers used the bricks, wood and materials that rendered the task more meaningful to them, and dairy workers based milk orders on inventive units of calculation by structuring resources within the situation. These strategies were flexible and adaptive depending on the context. As Scribner (ibid) concluded, 'skilled practical thinking is goal directed and varies adaptively with changing properties of problems and the changing conditions of the task'

(Scribner, 1985, p 39). Conversely, the manipulation of abstract rather than concrete symbols in school divides problem solving from reality (Reed and Lave, 1981)

A criticism voiced by Thompson (1989) suggests that Giddens has over-emphasised the enabling role of structure at the cost of underestimating the constraining role. The problem concerns the relationship between structural constraint and agency. Giddens suggests that agency is dependent on the individual having more than one choice. However, he also notes the possibility that constraint may reduce the number of choices an actor has, to only one. In this circumstance structure and agency appear again to be a duality in which structure can constrain and limit the options of actors to such a degree that the role of agency becomes insignificant. Thompson (ibid) suggests that in order to to confront these issues, a more satisfactory conception of structure is required, along with a clearer analysis of the wants and desires of actors.

The constraints of school structures are widely recognised. It has been accepted for some time that outside school children and adults invent their own procedures for solving problems and rarely use standard school methods (Fitzgerald, 1985). Similarly, in school children often ignore formally taught methods and secretly use their own informal ones, so presenting a 'veneer of accomplishment', and these informal methods are often devalued in the school context (Lave, Smith and Butler, 1988). Lave (1992) bases her evidence on research done outside school, but believes that in school there is a tendency towards contrived problem solving where teachers set highly specific aims requiring school type knowledge. She refers to the 'chasm between school and everyday life' (Lave, ibid, p 76). Outside school, children apply their everyday knowledge in practical situations. Conventional teaching in maths and science may over-emphasise formal problem solving procedures and prevent understanding by disembedding them from their applied context. Many children are consequently unable to cope with novel problem solving situations or to bring their own intuitive problem solving strategies to bear. They are, therefore, unable to bridge the gap between school taught knowledge and everyday practice and thinking.

Giddens' theory, on which Lave bases many of her ideas, also considers the work of social theorists such as Weber, Marx, Parsons and Levi-Strauss. It represents a major advancement in the conceptualisation of society, and focuses on many central themes of the present study, such as practical and strategic action, reflection, rules and resources, choice and change, power and control.

2.4.6 Apprenticeship in Action

Lave (1996) views both children and adults as lifelong learners, both in and out of school. In her book 'Understanding Practice; Perspectives on Activity and Context' she brings together problem solvers as diverse as ship navigators, doctors, blacksmiths and children in the classroom, and examines the contexts of their actions and intentions. In these portraits of everyday practice Lave acknowledges that adults and children may support each other as novice or expert. She is interested in how children and adult learners actively invent and make meaning in their learning in real situations. Lave's writing

considers the possibility of peer scaffolding for the individual apprentice, and the scaffolding of a whole group by either an older expert or a peer. Like Vygotsky (1978), Lave's ultimate aim is to give apprentices control over their own learning, and confidence to engage in critical analysis by both acknowledging their own intuitive strategies for problem solving and passing on formal knowledge and skills that may be useful within the specific context. School and everyday knowledge are thereby both valued and linked within authentic problem solving.

Being proactive as an apprentice in the workplace is seen as a natural and essential part of guided participation by Lave. She suggests that children themselves are normally eager to seek and share meaning and to take a significant creative role in structuring instruction and in influencing the nature and direction of scaffolding. She sees scaffolding and response as not only achieved through dialogue, but through gesture, action, type of task, physical environment and stimulating resources. But this is not always the case in school. Lave says that learning in the workplace is mediated by the apprentice's own initiative in not only responding but making suggestions and imitating the expert. Lave (1977) also suggests that craft apprentices establish through observation the criteria by which they judge their own work and correct errors. Azmitia (1998) suggests that simply observing expert partners plays an important role in scaffolding too, and has been shown to promote learning, but in school children's observation skills are known not to be extensive. Also, in the workplace children's motivation may stem from the commercial environment or from the enthusiasm of the master craftsman to pass on traditional craft skills, but this kind of motivation does not exist between teacher and child in school.

There are many practical problems when attempting to relate a situated cognition perspective to improved teaching and learning in the classroom. It implies that learning is most successful when embedded in authentic and meaningful activity, making use of the physical and social context and linking to the personal interests and aspirations of children, but this is easier said than done. It is suggested that expertise or mastery is gained through valuing and linking intuitive and spontaneous invention in response to the situation, to formal knowledge and skills passed on through apprenticeship. Supposedly, this builds on the tradition of the workplace in our society while encouraging innovation, and hopefully creates knowledge that is at once personal and useful within the culture. However, knowledge and skills gained in the workplace may be very different to those gained at school, and the application of a situated cognition perspective in school may be limited.

2.4.7 The Limitations of a Situated Cognition Perspective

There are important issues relating to a situated cognition perspective of learning which point to its limitations as a theoretical framework. Prominent amongst these issues is the question of *transfer*, or how context-specific theory accounts for the ways in which past experience may be carried across from one learning context to another. One of the most comprehensive discussions on the importance of transfer of learning was written by

Cole and his colleagues at the Laboratory of Comparative Human Cognition (1983). This group of researchers worked together on the paper 'Culture and Cognitive Development' (ibid), providing excellent insights into both Piagetian and Vygotskian psychology, including implications for understanding a situated cognition perspective. They traced the origins of competing approaches to cognitive development in the nineteenth century, in an attempt to synthesise the 'specific' and 'general' dichotomy that we often see today. This powerful paper cited the problem of *transfer* for a learning theory based on 'within context skill mastery'. It pinpointed extensive current research evidence (Johnson-Laird,1972; Gick et al,1980) that indicated the difficulty children experience in overcoming contextual barriers during problem solving. Consequently, it was suggested that there are grave limitations on the amount of 'spontaneous' transfer to be expected across the significant contexts of children's lives.

Cole et al (ibid) heavily criticise reliance on research in other cultures as models of activity in twentieth century industrial society, particularly those tied to technology, while describing major studies of apprenticeship in two different cultures. They first look at Lave's study of the training of young tailors in Liberia (1980), and then Greenfield's research with Zinacantieco child weavers (1982). In both cases adults guide practice by providing children with direct exposure to all the steps of the tailoring or weaving process at all times, so that from an early age, long before they might notice that they are learning to weave, girls 'witness the whole process of creating a garment', and young boys 'observe all steps in designing and making a suit'. This induction is skills based, but also represents specific enculturation into a social community of practice. Guidance is given through intervention strategies when novices are about to make a mistake, and through management of the environment, where only 'appropriate' resources are made available. Therefore, there are learning constraints through context selection but the problem is that all this knowledge and skill may be very context specific.

Cole et al (ibid) focus on written language as a universal tool for organising transfer, citing the need for a more powerful system of record keeping to facilitate trade during periods of rapid technological change, but this is tied very much to adult practice. More convincingly for children's learning, Lave emphasises an important point concerning *transfer* which applies to a great deal of our everyday problem solving. She says:

> 'Problems encountered in everyday life have been seen many times before. They are routine occurrences. This follows the general routineness of our everyday lives. The tailors come to work six days a week, make trousers, shirts and hats, alongside the same people they have been sewing next to for months, for customers many of whom they have known for years.'
>
> (Lave,1979 p 4)

The value of repetition is seen to minimise the problem of transfer posed by new and unusual problems. However, repetition is very much a feature of learning in everyday situations, but not of learning in school. Here children are expected to grasp ideas and

learn skills in one or two sessions and to remember them in other lessons. Also, importantly, repetition is a central feature of much craft activity but may play less of a part when children engage in new or inventive tasks. Perhaps a balance between repetitive context-specific activities and those which require novel ways of thinking should form the basis of most D&T tasks.

In the concluding pages of their paper, the Laboratory of Cognitive Development (ibid) offer broad areas of agreement between situated cognition and central processing theories. Here they use the analogy of the child learning to make pots with clay, in order to present the need to 'synthesise' cultural context and psychological models of cognition, towards a new 'cultural practice theory'. They argue:

> 'For a cultural practice theory, the craft of pottery making is simultaneously an abstract theoretical activity, implicating universal features of the world, an activity that reflects cultural constraints, and an activity that promotes individual skill and meaning. Because this activity simultaneously represents these psychological elements, we need a systematic method to capture its complexity and a unit that characterises both culture and cognition.'
>
> (ibid, p 344)

The group call for greater investigation into children's technological and cultural practice in modern Western settings, as a basis for an analysis of comparative everyday 'cultural practices' and comment, rightly, that efforts that closely model young children's experience in the world greatly increase our estimates of the abilities those children possess.

2.5 Two Theories of Intellectual Development and D&T

This chapter argues for a synthesis of cognitive theories. It can be seen how the work of recent researchers has been based on that of either Piaget or Vygotsky, and often influenced by both. Vygotsky and Piaget provide two theories of intellectual development, but neither theory was intended to be all embracing. What is interesting is that their work is complementary. Educators are constantly looking for the complete theory, or an all embracing 'recipe' for development but, as Popper (1972) suggests, it is never as simple as that. His advice was that if a theory appears to be the only possible one, you must take that as a sign that you have neither understood the theory nor the problem that it is intended to solve. Black (1998) maintains that there can be no 'correct' theory of complex fields of mental and social action. He feels that good theories should help synthesise previous empirical studies and stimulate fresh insights. This is true of both Piagetian and Vygotskian theory, but these theories were composed for different purposes: Piagetian theory in order to describe the construction of knowledge, and Vygotskian to illuminate the social aspects of learning. As Piaget's and Vygotsky's theories are complementary, they help to begin to create a balanced picture of how children learn: Piaget by showing how children construct their own knowledge through action, and Vygotsky by looking at how we acquire and use social relationships.

Inherent in both theories are differing perspectives of intellectual development. Kitchener (1996) argues that both Piaget and Vygotsky believed in stage laws, or descriptive emergence, but Piaget firmly believed in a series of paradigm shifts or qualitative changes in intellectual systems with age. This is an integration of the earlier into the later rather than a second stage being superimposed on the first, so that the elements of the earlier mental structure gradually knit together, but then that new structure becomes much more than the sum of its parts. There is, therefore, at each stage, integration and transformation of knowledge. Whereas for Vygotsky, intellectual development seemed to be a more gradual process, each phase representing new psychological systems which may completely replace the old, so that there is an explanatory emergence as new skills, new forms of thinking, and new attitudes towards the world develop (Van der Veer,1995). For Vygotsky, who formulated these views in the 1930s, this particularly entailed the explanation of perception, attention, memory and volition (Vygotsky and Luria,1974).

The growth of children's conceptual development is discussed by Carey (1986) when she questions whether there is really qualitative change during conceptual development or just accumulation. Carey, like Karmiloff-Smith (1992), suggests that the child develops several distinct theories to make sense of different realms of experience, and that knowledge is organised into distinct and somewhat independent systems, allowing for the fact that a child's understanding of some domains of knowledge may be more advanced than it is in other domains. This 'modular' view of mental development suggests that whilst the child's way of thinking exhibits structural changes throughout development, these changes are not of the global nature envisaged by Piaget's account of stages but are domain specific. Carey (1992) stresses the need to take into account the innate aspects of conceptual growth and maturation although she does accept that cultural tools and inventions can lead to the restructuring of knowledge and understanding.

Wood (1998) explains that in general, however, both developmental and modularity approaches stress the internal or 'endogenous' aspects of cognitive growth, viewing the process of achieving understanding as personal, active, selective and constructive, whereas social constructivist theories of development stress 'exogenous' influences such as culture or instruction. These different views of development are complex, but it is important to understand them because young children's problem solving strategies in D&T may change or develop during Key Stage 1, and an appreciation of these major theoretical positions should inform the present study.

2.5.1 The Relevance of Piaget's Work

• Piaget was the first to stress that learning is active and that practical activity for children is the engine of their learning process. D&T is based on learning through practical action.

• Piaget as a constructivist, saw young children as constructing their own knowledge through their own actions and activities.

• Piaget saw children as learning at their own pace while following similar developmental patterns as others.

• In Piagetian theory children are seen as self-motivated, active learners, who think qualitatively differently from adults and whose development is influenced by environmental experience.

• Piaget's work demonstrated that children bring everyday knowledge, such as experience of classifying and ordering, to school learning. Through his work we can appreciate the difference between problems outside school and those set in the classroom.

• His work also helped us acknowledged the importance of seeing from another's perspective. D&T encourages children to understand the needs and values of others and recognises the importance of being aware of different perspectives in order to make design decisions.

2.5.2 Vygotsky's Work and D&T

In relation to technology education, Vygotsky's work suggests that young children's individual problem solving strategies have social origins. Their learning initially takes place in the everyday interactions of domestic life. Within these general problem solving situations, opportunities are available for more capable members of the household to assist and regulate child performance. In this way children learn the accumulated wisdom and strategic tools of their culture. At first they are lured into the activity purely by the pleasures of social interaction, but as they begin to make sense of problem solving situations and develop understanding, they start to generalise their new skills to new problems or novel aspects of familiar situations. Vygotsky's ideas are relevant to young children's design and technology education today and inform the present research in the following ways:

• Vygotsky viewed culture as the accumulated knowledge of people encoded in the language of their made environment, artefacts, systems and values. His work suggested that technology, as human endeavour, shapes the development of society and in turn

the learning of children within it.

• He believed that children are initiated into an established technological community and that their problem solving strategies can only develop within the boundaries of this cultural and technological context. They are constrained by the existing body of technical knowledge, the language of technology and the practice and values acceptable within the social rules of the classroom culture.

• Vygotsky argued that the use of technical tools develops problem solving skills. Therefore, psychological tools may be acquired through technical tools. This means that children's problem solving strategies may be seen as developing through the use of physical design and technology tools, and the symbolic representations of models, plans, drawing and other forms of imaging.

• His work suggests that the development of children's individual problem solving strategies has social origins. Children's mental processes are guided by adults or by more competent peers. In order to assist learners effectively, teachers often need an extensive knowledge, especially in a relatively new subject such as D&T. Children need to be able to collaborate with each other, and to work in pairs or groups.

• For Vygotsky, the problem solving of early school aged children includes a striving towards self regulation because through scaffolding they begin to internalise knowledge and use it as a tool for conscious control. At this stage children increase responsibility for their performance through self directed speech and gradually begin to enter into social negotiation with teachers or peers.

• Vygotsky was interested in children's potential and in joint collaboration through a gradual transfer of responsibility from the adult to the child. D&T fundamentally concerns control and change, and in D&T activities it is important to allow children some ownership of the task, and time and space to make their own decisions with support to extend their thinking, but often without intervention.

• Vygotsky saw the pattern of learning throughout life mirrored in the moment-to-moment problem solving process used during one task. It follows that the process, in the form of cognitive strategies, used in design and technology tasks may illuminate aspects of learning throughout life.

2.5.3 Developing Problem Solving through Collaboration

The work of Doise and Mugny, Perret-Clemont and Galton, as well as Goffman's work on gender, has informed the present study concerning collaborative groups and D&T. Collaborative group work may help children develop problem solving strategies in design and technology education because:

- Collaborative work allows children to act together to creatively shape and reshape their environment.

- It can empower children to devise help giving and help seeking strategies to solve practical problems.

- Working with peers creates adventure and challenge in which children meet new friends and learn to develop strategies for handling social uncertainty and conflict.

- Working with peers can accentuate, but also heighten awareness of, gender differences and help teachers and children work towards more flexible attitudes.

- Collaboration in D&T can enhance learning and provide realistic situations in which children can explore their needs as users, and develop technological vocabulary.

- It can allow for the development of personal and social skills such as confidence, perseverance, cooperation and empathy.

- Working with peers can give children the opportunity to take joint responsibility for design outcomes and technological products, and encourages citizenship.

However, it is also necessary for children to understand what they can do as individuals. Too much sharing may damage feelings of identity and self-esteem. It is important for children to know what they can accomplish alone and unaided and to feel complete ownership and responsibility.

2.5.4 Situated Cognition and Primary D&T Education

It can be seen from the previous sections that it is necessary to be circumspect in attempting to use aspects of a situated cognition perspective to inform research in design and technology education. There are a number of limitations that present drawbacks, and the problem of transfer is central to this discussion. McCormick (1996) argues that research on expert problem solving and situated cognition points to the conclusion that the idea of a general problem solving capability, which can be used in a variety of situations and transferred across contexts, has little empirical justification. Research shows that what problem solvers of all ages in everyday and workplace situations actually

know and do often bears little relationship to what goes on in the classroom, which can be rather an alien culture and lacking in relevance to everyday thinking outside school. From his research on problem solving (PSTE, 1995), McCormick has stated that technology tasks make greater demands on children's conceptual and procedural knowledge than is often realised. He indicates that many of their difficulties in designing and making are based on an inability to transfer skills from one situation to another, and

> 'stem from lack of relevant knowledge and skills, an inability to draw on knowledge from relevant teaching and on knowledge learned in other contexts (despite teachers' assumptions of transfer), as well as lack of sufficient experience of appropriate materials and tools'.
>
> (McCormick, 1995, p1)

McCormick's work was done in secondary schools and he was talking of older pupils, but there is no evidence that suggests that younger children are able to transfer skills any more easily. There are also different types of transfer: transfer of specific subject knowledge, and everyday and school knowledge. Perhaps because the early years curriculum is more subject integrated than the secondary curriculum, there may be more likelihood of knowledge transfer across subjects. Primary schools often take care to maintain everyday and school links within the curriculum, so this perhaps increases the possibility of transfer of problem solving strategies from home to school.

Situated cognition theory describes adults and children working together to gain knowledge and skills and to solve problems. It describes teamwork in common practical settings outside school, but in school children are assessed as individuals (Resnick,1987). Even when group work is apparently valued, in practice children seated in groups often work alone (Galton et al,1980). A situated cognition approach also assumes that the scaffolding that may take place naturally in the workplace between the expert and apprentice is commonplace in schools, which is often not the case (Bliss, 1996). Outside school, problem solving is self motivated, with authentic problems that are relevant to the learner, rather than artificially constructed by a teacher or a prescribed design and technology curriculum. As McCormick says, 'the strength of the real world context is often missing in practice' (ibid). Real problems, from personal or social needs or local community, cannot readily be transposed into the artificial surroundings of the classroom. Often pupils tend to rely on textbook solutions to problems that teachers pretend to be 'real-world' (Schoenfeld, 1987).

In addition, situated cognition, especially of the type advocated by researchers such as Lave, seems to assume universal cross cultural methods of apprenticeship and guidance that are similar in both Eastern and Western cultures, whereas the technology is often very different. So what can situated cognition bring to the study of design and technology, and how will it inform the present study? Certainly it did not seem to support the research of McCormick, Hennessy and Murphy (1993), as they struggled to identify pupils' problem solving strategies within the restrictive and differentiated timetable of the

secondary school. They relate turning to the literature in desperation and finding very little guidance. But looking in depth at the work of Lave, it is clear that she describes apprentices experiencing the whole process at all levels and from an early age (Lave, 1988). Here the process is seen as a unified whole, allowing for spontaneous skill emergence. In the secondary schools of McCormick's study, the design and make process was divided into isolated lessons, or sub-processes, of either design drawing, researching, making or evaluating. This may have restricted and even prevented pupils' spontaneous skill and strategy formation.

Another limitation of a situated cognition perspective is that although Lave and Greenfield's expert weavers and tailors are careful to make skills explicit to their apprentices, it is essentially a *making* process with a strong craft focus. Apprentice weavers and tailors imitate rather than innovate. There is little mention of originality of design or creativity in Lave's work, and it is not clear whether skills and traditions are passed on unaltered by fashion or fancy in the workshops of her study. If a key aim of design and technology is to enable pupils to act as responsible apprentices within everyday contexts so as to learn how to shape and improve the technological world, it should also enable them to become discriminating citizens and consumers. This requires autonomous thinkers as well as skilled entrepreneurs. Certainly working within a community of good practice helps children to critically evaluate their own and commercial products, in order to assess the benefits and problems for themselves and the user, but does this help them to recognise conflicting requirements by responding sympathetically, imaginatively and inventively? Will it also help them to devise their own strategies to speculate, visualise, discuss, plan, model and evaluate potential solutions to realistic problems?

Although in Lave's descriptions there seems to be a strong element of control of the process by the experts, the collaboration of novice and expert in the making of a single garment is emphasised, so that all stages of the process are experienced, or at least witnessed, by all apprentices, and the importance of quality and a high standard of finish is stressed. The demands of the marketplace also necessitate a strong awareness of design specifications matched to the end product, whereas both McCormick's (1993) and Kimbell's (1996) research highlight the lack of specific requirements by teachers in terms of design criteria for classroom D&T tasks. In balance, Kimbell's research also indicates the dangers of too much teacher control of the D&T process in schools. In schools there seems little evidence of shared ways of working by teacher and child in the way described by Lave. In fact it is generally considered bad practice for a teacher to personally alter or finish a child's work. This close paired working relationship is more likely to be found in children working with peers. The balance between the constraints of teacher control in passing on skills and child opportunity for challenge and decision making is an important consideration in National Curriculum Design and Technology education.

In summary, a situated cognition perspective is only partially suitable as a theoretical frame to the present study. Certain aspects are useful: for example, it is crucial

that children have the opportunity to use their everyday knowledge and skills to devise strategies to solve real problems moving towards greater collaboration, confidence and mastery. It is also important that it be recognised how the context of a task affects children's skills and strategies during problem solving, but that transfer of learning across contexts cannot be assumed. Other aspects of the model are also problematic. These are concerned with how children might be 'inducted' into processes which draw upon industrial and cultural models, and how they might share work with more experienced adults or peers, so witnessing the whole process of designing and making. Situated cognition cannot stand alone. It appears necessary to draw together elements of various approaches to create a theoretical background for the present study.

2.6 Summary

In conclusion, the eclectic approach of this chapter aims to synthesise theories to help explain learning in design and technology. It can be seen that two major theories, those of Piaget and Vygotsky, complement each other in their emphasis. Theoretical approaches built on these, such as socio-cognitive conflict and aspects of situated cognition, also combine to inform learning in different ways. A situated cognition approach to learning, based on Vygotsky's cultural model, is useful but it must be combined with elements of Piagetian active learning. The success of design and technology education depends on teaching young children not only the knowledge and skills that experts possess traditionally, but more importantly the ingenuity and creativity to tackle complex problems in the modern world. Hennessy (1993) argues that this tacit, strategic knowledge includes both cognitive and metacognitive processes, and ideally incorporates problem solving strategies and control strategies. It also includes knowledge about how to learn, which entails general strategies for exploring new domains and local ones for reconfiguring knowledge (Collins, Brown and Newman,1989). It is important that children are able to design creatively as well as make skilfully. It is also essential that they are encouraged to react spontaneously to challenges and have scope for decision making. Authentic D&T problem solving in school may 'give children the opportunity to observe, engage in, construct or discover expert strategies in context' (Hennessy, ibid). But this is often difficult to translate to the more formal curriculum of the classroom. The emphasis should be on developing the learners' strategic resources, rather than teaching set routines. Teaching children to value and use their own strategies is crucial if they are to explore problem solving successfully (Edwards and Mercer,1987). It is also important that transfer of learning from one context to another is seen as problematic and not taken for granted. Careful scaffolding by adults and peers often needs to take place to provide those links. Through D&T tasks young children can be exposed to their culture's technological way of thinking and its technical vocabulary and values, and can develop in collaboration problem solving strategies that underpin these. Sadly these strategies are rarely observed by research in the primary classroom. The following study provides an opportunity to do this.

Chapter 3
Methodology

3.1 The Aim of the Research

The aim of the study was to see how children's problem solving strategies develop when tackling D&T tasks without heavy guidance from an adult. Careful consideration needed to be given to how this could best be done. What was the most appropriate way of exploring the sorts of goal oriented activities that children used spontaneously during design and technology tasks, and how could this be done in a way that could contribute to the shared body of knowledge of academics and teachers? It was decided to work with groups of children in two schools, trying to observe their strategies during problem solving in their first term; and then to follow the same groups through Key Stage 1, observing their problem solving strategies at certain intervals. It was thought most appropriate to watch the children engaged in typical design and technology tasks in their classrooms using standard tools and materials.

3.1.2 Research Questions

There was a qualitative approach to the research design, based on the research questions. The following questions were asked:

* To what extent can we identify and classify the intuitive problem solving strategies that young children bring with them to design and technology tasks?

* Is it possible to specify the nature of these strategies and the relationship between them in a taxonomy ?

* Do these strategies change in relation to D&T tasks and resources?

* If children are followed longitudinally over a period of three years, can a development or change in strategies be seen?

* If so, what is the nature of that change over Key Stage 1, and can it be explained?

3.2. Rationale for a Longitudinal Study

This is one of the first longitudinal studies of young children engaged in D&T tasks at Key Stage 1. Unlike most longitudinal studies, however, this research follows groups of children and not individuals. A basic requirement of the Design and Technology National Curriculum is that children should work collaboratively, and the premis on which this research is based is that children's problem solving strategies develop within a social setting. It is lengthy to talk continually of groups of children, but it must be stated that throughout this study whenever children or pupils are mentioned, it is groups of children that are referred to and not individuals.

During the work it was thought important to explore children's strategies over a number of different D&T tasks using the full breadth of resources and materials, and in a range of familiar contexts. The chance to go further by attempting to trace changes in the children's strategies throughout the infant school was considered an exciting opportunity.

This study attempts to identify group problem solving strategies during their first years in school, but without longitudinal evidence it is impossible to consider if the groups strategy patterns, identified at the beginning of Key Stage 1, remain constant or change as the children grow older. It is difficult to know if strategies develop or decline, or if new strategies or patterns emerge, and at what age and under what conditions this occurs. A longitudinal design then, would seem the ideal way to study strategy change, as it fits so closely the requirement that development be studied over time.

3.2.1 Longitudinal Studies and D&T

However, longitudinal studies have drawbacks, and there are specific difficulties when studying children doing design and technology in naturalistic settings. Certain problems occur when aiming to reflect upon what happens in normal classrooms. Ideally, for a longitudinal study, the tasks for children should be as similar as possible in order to trace progression through Key Stage 1. At regular intervals children in Year R, Year 1, and Year 2, in both schools, should design and make the same type of product, for example, clay gifts. Sadly, this was not possible within the context of the study. The researcher was very much bound by the teachers' schemes of work for that term. The National Curriculum (1990) had been introduced during the previous three years and was still relatively unfamiliar, and teachers were nervous about working outside the boundaries of the Statutory Orders. They were uncertain about this new curriculum area of design and technology, and took advice from the subject coordinator and head teacher when planning schemes of work. These documents tended to be prepared for the whole school so that classes could work through them in turn. Schemes of work related to programmes of study, and were often tightly prescribed because care had been taken to cover certain aspects of the curriculum within a set period of time. Year groups often worked together so that two or three classes were timetabled to do the same tasks in rotation. This set certain expectations concerning the nature and storage of children's

products and the use of resources. Often tools and materials were lacking, for instance, there were few junior hacksaws and bench hooks, and even a lack of sandpaper. Usually resources were shared so that, for example, only one group at a time could work with food. There was little flexibility about when equipment could be used.

The external pressures on schools, and teachers' lack of confidence in teaching design and technology, worked in favour of gaining access to the classroom, because schools were conscious of needing support, but against creating a traditional longitudinal design. It seemed impossible for schools to adopt the tasks devised by the researcher so that children would be doing the same or similar tasks each year. Even when the task was as straightforward as greetings cards, teachers were concerned that progression should be built into the activity, so that, for example, greetings cards in Year 2 might include simple mechanisms, changing the task radically. When using the same activity over a period of time with the same children there are other drawbacks concerned with children's learning. In this case pupils might be prompted, by association, to use the same strategies again. There were dangers in terms of reliability in the researcher being known by the children as 'the card lady'. Also the range of tools and materials used in design and technology are so extensive that if all children in the study in both schools used all of these at regular intervals it would generate far too much data.

A compromise needed to be found so that a longitudinal study could be undertaken within the constraints of normal primary classrooms. This was done in negotiation with individual class teachers and other professionals in the schools. It was found that Reception teachers were extremely concerned about safety hazards involved when very young children work with hard materials, such as wood, and associated tools. Consequently, the longitudinal design included hard materials in Years 1 and 2, but not at Reception level. Tasks were planned to be as similar as possible while still working within the schools' schemes of work, so that hard materials were used to make buildings at Year 1 and rain forest shelters at Year 2. Similar compromises were made throughout the research design so that a range of materials and tools could be used by the children in the tasks. Sadly, it was not possible to include food as a resource in the study. The difficulties described have obvious implications for pupil progression and teacher assessment in schools, but in the present study a negotiated longitudinal design was accomplished.

3.2.2 General Drawbacks of Longitudinal Designs

In addition to this, all longitudinal research designs in education have some practical drawbacks that can threaten their reliability. They can be long and require perseverance and commitment from both the pupils and the teachers concerned. It took four years to collect the data for the present study, during which time there were changes in the teaching staff who had originally agreed to participate at both the sample schools. The major problem with longitudinal studies, however, is that some children may drop out, so changing the sample in a way that may slightly weaken the data. Fortunately, in this study, from a sample of 36 children, only four left the schools during data collection, and the groups were augmented by other children of the same age and sex from the same

classes.

An additional difficulty with longitudinal designs in general is that the children in the sample may become accustomed to the various research procedures, such as testing or interviewing, and may learn how they are expected to respond. In this study the children's response to the visits of the researcher, who introduced the tasks and provided materials, may have encouraged them to employ certain types of strategy, but this would be difficult to verify. An awareness of this possibility during data collection led to a conscious effort by the researcher to introduce the task in as straight forward a way as possible and then take a low profile observation stance during the children's designing and making in order to avoid prompting children towards strategic choices.

Finally, longitudinal research designs may confuse the influence of age-related changes with other sources of change. For example, in the present study any change in children's strategies could also be attributed to the quality of teaching at a certain stage rather than age or capability of the children. To some extent the researcher acting as teacher/observer at every session throughout the study may counteract this, but of course the influence of the class teacher on the strategies of the group cannot be denied. It was because of these difficulties that it was thought important that more than one school was used in this study: not to provide two contrasting samples, but to replicate as far as possible the first school in order to verify the findings in a similar context.

3.2.3 The Context of the Research

Two Hertfordshire primary schools that were well known to the researcher were chosen for the study. It was felt important that the researcher should have a full understanding of the policy and practice of design and technology in the schools, as a certain way of teaching may affect the strategies of the children participating in the research. The schools were in a middle income area of a London commuter town often used for polls and sampling, as it is said to have a population that in cultural and socio-economic terms is representative of the country as a whole. The schools were very similar in both social and physical context, with an upper working class, multi-ethnic intake, although one was a primary school and the other an infant school.

Visits were made to discuss with the head teachers and staff the viability of a three year commitment to the study and the ethical issues surrounding recording and photographing children. Practical ways of working with small groups of young children in the classroom were devised, and means of attempting to observe and record the strategies children use to tackle design and technology problems were agreed. It was important for the researcher to become familiar with the children, staff and classroom practice so that children could tackle the design and technology tasks in a context where there would be as much freedom as possible for spontaneous strategic action. For this reason, the end of term and certain afternoon sessions were chosen as the most relaxed times, when children had maximum control over their learning.

3.2.4 Policy and Practice in the Two Schools

The reason for using two schools in this study has already been mentioned. This was to replicate as far as possible the first school in a similar context. To do this, two very similar schools needed to be found so that the children came to the research tasks with similar experiences and expectations. This similarity was required not only in terms of location, number of pupils and type of intake, but in the way design and technology was taught in the schools. Despite the fact that Gorden Park Primary School and Waterfields Infant School were very similar in all aspects, certain differences still existed in the way D&T was taught. This section will focus first on the similarities and then the differences.

There were fundamental similarities in the way D&T was taught at Key Stage 1 in both schools. This was primarily due to the strong advisory service and inspectorate operating in Hertfordshire at that time. The policy and values upon which Hertfordshire had built its education service were detailed in its Primary Curriculum Statement (1988). It argued for:

*Entitlement for all children to high quality education regardless of race, gender or ability.

*Achievement through integrated cross-curricular learning.

* Relevance of knowledge and skills to pupils' experience.

* Continuity and progression reflecting previous learning.

* Purpose and challenge for all pupils in school.

It is easy to draw parallels between Hertfordshire's educational principles, which were transmitted to all schools through regular and powerful INSET, inspection and advisory visits, and the processes of D&T. In D&T there is an emphasis on the 'active' child responding to challenge through purposeful and relevant problem solving, and a cross-curricular approach to learning within a democratic philosophy. A picture of a process-driven, integrated curriculum emerges from Hertfordshire's policy, where 'knowing how' and 'knowing why' are as important as 'knowing what'.

It was against this background that the first National Curriculum Technology Orders (1990) were introduced, and Hertfordshire was in a strong position to respond. It did this by appointing a large group of new advisors and advisory teachers to create conference and exhibition based induction of newly appointed school coordinators into the principles and practice of primary Technology education. A Technology activity pack arrived in all primary schools, including information, photographs, action plans and an audio tape to explain this new curriculum subject. The perception of Technology embedded in this induction pack was of a subject that 'built on good primary practice' as envisaged by the local authority, 'enabled children to show originality, enterprise, and adaptability', and depended on 'children controlling things, not things controlling children' (Hertfordshire County Council, 1990). In this way all schools, including both schools in the present study, adopted the same perception of Technology. But it is also important to say that many other LEAs promoted a very similar pupil-centred view of the subject at that time.

The schools implemented the Technology Curriculum accordingly. Both Waterfields Infant School's scheme of work, and that of Gorden Park were drafted with firm guidance from the Hertfordshire Technology Policy Guidelines (1991), and under the personal direction of the same advisory teacher. When the present study began in 1992, Waterfields Infant School's Technology Policy (1992) stated an agreed definition of technology: 'Technology is designing and making useful things through a problem solving process'. Gorden Park's Policy Document (1992) provided a similar definition: 'Technology is the creative activity by which we solve practical problems'.

By the end of the data gathering in the schools, in 1996, the Revised National Curriculum for Design and Technology (1995) had been introduced and both documents had also undergone some revision, although the continuing advisory support meant that they remained very similar. Now the definition of design and technology at Waterfields read: 'Design and Technology is the creative application of knowledge, skills and understanding to design and make good quality products', and Gorden Park's definition stated that: 'D&T develops children's capability, through combining their design and make skills with knowledge and understanding, in order to design and make products.'

The planning and teaching of D&T in the schools had also progressed but a pupil-centred ethos still prevailed. The D&T coordinator at Waterfields remarked in discussion: 'We need to listen to children and give them time to solve problems,... not to step in too soon. The process is just as important as the product'. A teacher at Gorden Park said ' I would like to feel that the children and myself cooperate so that we all take decisions. They appear to have faith in me and I have confidence in them, but I sometimes find myself taking over'. These comments highlight the values and assumptions underlying the practice of D&T in both schools.

On the whole, the policy documents were reflected in classroom practice, but obviously there were differences between the two schools in the study. These were mainly of an organisational and managerial kind. Waterfields Infants was a much smaller school than Gorden Park Primary, and as such had a more cohesive focus, concentrating exclusively on early years education. They organised and planned their teaching well in advance but were able to be flexible about adhering rigidly to schemes of work. The school allocated seven weeks (5.25 hours per week) to Design and Technology in their long term yearly plan. This covered the progression of knowledge and skills, and specific D&T tasks such as designing and making cards, clay gifts, puppets, and toys with hard materials. Medium term plans were made by teachers across year groups with reference to these.

Gorden Park was built over a large site and included Infant and Junior departments. The management strategy was tightly focused on continuity and progression of learning from Infant to Junior department, and schemes of work were designed to help pupils move through the school, learning and reflecting in a systematic way. The D&T policy began with a simple circular process diagram, and then set out a matrix showing progression in three areas: Research Skills, Design Skills and Evaluation Skills.

Certain tasks were set down in the ongoing timetable for lower school (YR-Y2), middle school (Y3-4), and upper school (Y5-6). The tasks were chosen so that pupils would use a range of resources, starting with simple sheet materials at Key Stage 1, and moving to hard materials and electricity in the Junior departments. These tasks included at Key Stage 1: Greetings cards, defined as a sheet material task; puppets, using textiles; homes, using hard materials; and vehicles, using Jinks frames. It proved possible to negotiate with the D&T coordinator and class teacher so that flexibility could be introduced that would allow these tasks to be modified. They were combined with those set out in the Waterfields schoo'sl scheme of work where some compromises had also been made so that the researcher could engage in a longitudinal study in both schools.

3.3 Research Design

3.3.1 The Sample

The study began in the reception class at Gorden Park Primary School in December 1992. A class of 18 children was used in the research. These children were organised by age into three groups of six children. The oldest group were over five and a half years old, the middle group were between five and five and a half, and the youngest were just five years old. Two groups had started school at the beginning of the school year in September and one just before Christmas. The children were selected for the group on the basis of age, gender and cultural background. In each group of six there was an attempt to mix children equally in terms of gender and culture. Care was taken to ensure that this class was representative of the composition of the school's reception classes in general. For the purpose of the study the three groups worked on a design and technology task in December and another six months later in the summer.

A second class of children in another school, Waterfields Infants, joined the study in 1993, a year after the first. 18 children were selected to replicate as far as possible the age, gender and cultural background of the first groups. Again these groups of children were traced throughout the Infant school engaged in D&T tasks in the same manner as the classes at Gorden Park. The complete sample therefore consisted of 36 children, 18 in each school, with each class organised into three groups according to age and experience in school.

3.3.2 Data Collection

The data was collected in the form of audio recordings of the groups' verbal responses to the D&T tasks, field notes of all observed sessions using naturalistic observational methods with particular attention to children's action and interaction, and photographic evidence to support this. The combination of these data sources provided detailed and annotated transcriptions of most sessions.

It was decided to gather the data through the use of audiotape for a number of reasons. Firstly, this method allowed the researcher to record all the children's dialogue and activities 'live' in the classroom while, at the same time, allowing her to supplement this with written observations of children's actions. Secondly, it released the researcher to

act as an active 'participant teacher' while introducing the task to the children, and as a passive 'observer teacher' while the children were engaged in the design and technology activity. Thirdly, the children in both the schools were accustomed to the use of audiotape and often used it themselves in other curriculum subjects. Indeed, on a number of occasions they asked for the tape to be played back and were able to clarify through group discussion the researcher's understanding of what had taken place during the design and make task.

It was decided to use audiotape supported by observation in preference to video tape because the children were familiar with its use. They were not accustomed to working with video equipment and it was feared that they would 'perform' for the camera. The class teachers were very doubtful about the practicalities of introducing video into their classrooms as they felt it would be intrusive and might limit the scope of the observations, since children engaged in D&T are necessarily mobile. They were also afraid that it might constrain their own work with groups of children in other areas of the classroom.

Naturalistic observation was used as a means of data collection in the hope that this would yield the essential information needed to identify and understand children's strategies from their point of view. It was felt necessary to try to capture the children's actions in as natural and unconstrained a context as possible, giving the children maximum control over their learning. Therefore, help and intervention was kept to a minimum during the problem solving activity. The complete lesson, with introduction and children's verbal responses to the task, was audiotaped and observational data and photographs were collected concerning the children's actions and social interactions with peers. This was done so that the focus was equally on verbalised strategies and observable but inaudible task adequate problem solving behaviour. The aim was to collect both children's utterances and actions together in context.

The observation notes themselves were not taken in the form of a planned schedule, as in much of the original research using systematic observations, as this was felt to pre-empt or pre-select the type of events that might be noted by the observer and so prevent authenticity. Rather, diagrams were made of children's seating and movement, and shorthand notes were taken of all actions and interactions that could not be explained by the tape. To support this a photographic record was made of complex action and interaction during the design and technology activities and of the children's finished products.

3.3.3 The Role of the Researcher

The researcher had taught young children for a considerable number of years, and had worked as an advisory teacher for design and technology in two local authorities before beginning to train student teachers in the subject. In this research she worked in the classroom alongside the sample group who were undertaking the design and technology task. She took a dual role, first of participant and then of observer. She had greater participation in the session at the beginning when she was introducing the task

and the resources to the children, and much less during the children's practical activity while she was writing field notes and taking photographs as an observer. This dual role of distinct phases of participation and observation is often used by primary teachers during assessment of children's achievement.

At the start of the session the researcher presented the task in as straightforward a way as possible. She answered the children's questions but tried not to led them towards ways of tackling the activity. After a short introduction, as the children set about designing and making, the researcher's role moved from an active participant to a low profile observer. Although still maintaining a teacher presence, a passive stance was then taken with very little instruction or teaching and minimal conversation. A watching, listening and note-taking role was maintained as the audiotape recorded the children's talk, and occasional photographs were taken. If the children asked for physical help it was given but care was taken not to directly scaffold children towards learning or influence their choice of strategy. It was felt that this did not disadvantage the children's learning during the activity. Sometimes teachers unconsciously intervene in ways that inhibit pupil progress, and it was felt important to give children the freedom, time, space and interesting resources, so that they could tackle their own D&T problems and use their strategies in a flexible and creative way.

3.3.4 D&T Tasks Used in the Study

The tasks were chosen with a number of criteria in mind. Firstly, that they should be representative of typical design and technology problem solving activities engaged in by primary children at Key Stage 1; secondly, that they should give the children the opportunity to engage in problem solving strategies using a variety of tools and materials in a range of familiar contexts; and thirdly that they should provide scope for groups to exhibit and develop strategies in both a collaborative and autonomous way.

The tasks in the study were viewed as developing from a breadth of contexts relating to everyday problem solving and linking home, school and the community. The importance of real and relevant contexts for children's design and technology is reflected in these tasks, where outcomes or products are described in relation to the needs they meet. The research tasks were designed to give opportunity for this and emphasise peer collaboration. It was hoped that the role and importance of group discussion in helping children to develop their design ideas, skills and strategies may be revealed, through the process of problem solving, the stimulus of the tasks, and use of tools and materials. The range of tasks undertaken in both schools is displayed in the task matrix below (Table 1).

Table 1. Matrix of tasks, schools, ages and times of data collection

For three groups of children in each class: oldest, middle and youngest

Tasks	Class	Gorden Park Primary	Waterfields Infants
Greetings cards	YR	December 1992	December 1993
Invitations	YR	July 1993	
Portraits	YR		July 1994
Clay gifts	Y1	December 1993	December 1994
Buildings	Y1	July 1994	
Toys	Y1		July 1995
Moving vehicles	Y2	December 1994	
Puppets	Y2		December 1995
Shelters	Y2	July 1995	
Thank you cards	Y2		July 1996

The range of tasks used was drawn primarily from the current class topic or scheme of work at the time of data gathering. To use tasks already planned by the class teacher seemed the most appropriate way to set them in contexts that were real and relevant to primary children, and therefore form authentic activities. Tasks common to most primary classrooms at certain times of year, such as designing and making Greetings cards, were done in both sample schools. Other tasks such as invitations were changed in the second school so that they matched the teacher's planning, but a task such as collage portraits was chosen so as to provide similar learning opportunities and the use of tools and materials.

The tasks were designed to prompt children's use of problem solving strategies by providing the usual wide range of materials found in the infant school. In addition to rigid collage materials, textiles, and graphic media at Reception level, modelling clay was introduced at Year 1 and resistant construction materials were used in the tasks for all groups at the end of Years1 and 2. In Year 2 the children again used a combination of hard and soft materials to design and make so that the results might be compared to those of earlier sessions.

A variety of tools were provided for the children during problem solving. There was not the limited range of tools for younger primary children sometimes specified in the literature but a realistic and full complement. The children were asked to choose from, and use appropriately, a wide range of tools and equipment from simple cutting and joining tools, such as scissors and glue in the reception class, to drills and sandpaper and needle and thread later in the study.

3.3.5 Task Conditions

There was a conscious effort throughout the research to use the same tasks, keeping them as similar as possible despite the changes in teachers and classrooms as the children moved through the two schools. The task situations were monitored to ensure continuity. For example, all D&T tasks were carried out in normal classroom settings, with the class teacher and assistants working with other groups of children nearby. All tasks took place in classrooms where the children were accustomed to working, rather than in adjoining areas or spare rooms in the schools. The children were able to choose their place at a central table where they worked alongside their peers, and they could choose to create individual, paired or group products related to the task. They also had free access to tools and materials normally available in the classroom and stored nearby, and they could move about the room freely. There were no restrictions on the tools or materials available from other areas of the classroom, such as construction kits or reclaimed resources.

Before each session the role of the researcher was explained to the children and their permission was sought to use the audio recorder during the task. It was usually agreed that it should be played back to the group after the session so that they could hear themselves. The children's permission was also sought before photographs were taken but they often asked to be photographed with their work during and after the session, or to use the camera themselves. Although each task took approximately an hour for the group to complete, the comparatively short concentration span of young children was accommodated by providing a range of activities within the task, such as introduction and discussion, short evaluative tasks such as looking at commercially made products, and practical designing and making. All finished products were considered the property of the school or children.

The role of class teachers during the research was negotiated prior to the study and was kept constant throughout the work. They were responsible for the integrated learning activities of the rest of the class while the researcher took responsibility for the sample group. However, class teachers always took an active interest in the research and asked questions or discussed the design and technology activity with the children and the researcher after the session, and often arranged to extend the task within the curriculum or display the work and photographs in the classroom.

3.4 Means of Analysis

3.4.1 Phases of analysis

The study generated 36, one-hour audio tapes and associated material. Various coding methods were used to analyse the research data but the overarching approach was qualitative. The analysis was done in three steps, although it is emphasised that these were closely interrelated. The three steps were :

Step One: The construction of systemic networks. These were used in a pilot study at the beginning of the analysis in an initial attempt to identify the problem solving strategies that young children bring with them to design and technology tasks when they first enter school. They were used again at the end of the reception year to see if it was possible to trace any change in strategy use throughout the first year of school.

Step Two: The classification and characterisation of the strategies previously identified to create the beginnings of a taxonomy. An attempt to codify the transcripts with the initially identified strategies using these strategies as units of analysis to generate a general taxonomy.

Step Three: The revision of the taxonomy for different types of task and groups of children. A gradual reclassification and recharacterisation of strategies to modify the taxonomy for different tasks, resources and age groups. This was done by first considering the strategies in terms the resources used, that is the materials and tools, which differed in the different tasks, then considering the strategies longitudinally over three years and looking for development or change as the children grew older.

3.4.2 Step One: Systemic Networks

Systemic networks were used to try to identify the children's strategies and represent them in a form which allowed the task to be seen through the child's eyes. Time and care was taken to match children's utterances to their actions and to sort and classify these using the network apparatus as a tool. The systemic networks created aimed to both categorise and describe the children's strategies and to distinguish their options or choice of action. In order to achieve this the children's individual responses were grouped into categories that were dictated by sections of the D&T session and, within these, strategies in the data itself. For example, at the beginning of the session starting strategies seemed to revolve around the children's choosing and using materials. Within this broad theme it was then possible to identify greater detail, for instance aspects of children's choice when they began to work, such as colour and texture and individual or shared choices, so that greater levels of delicacy could be included in the network.

The networks aimed to display the relationship between these choices, children's own wants and needs and the constraints of the context. The networks served as both an analytic coding and a representation device. They helped to deal with a long and complex set of transcripts in a systematic way, and helped to provide some general insights through the use of coding, grouping and classifying procedures. They allowed this work to be represented in a succinct yet detailed way using simple jargon-free terminology. The networks were used to categorise and sub-categorise children's strategies as they moved through the task. In this way it was possible to distinguish between the different strategies children used and to name them. Names were drawn directly from the children's own language while using the strategy. Various aspects or properties of a strategy formed sub-categories. The complex nature of these strategies and the relationship between them is indicated through the notation. The BAR notation, consisting of a vertical line with a distinct category to the left and subcategories to the right, indicates the choice of strategy the children exhibit within the main category, and sometimes clarifies the contrast and extent of these choices. The BRA or bracket indicates a co-selection of strategies. Children within a certain aspect or phase of the design and technology task will necessarily exhibit the full range or sequence of strategies indicated. Through the notation the reader may see at a glance not only the general categorisation of children's strategies but the choice within and relationship between these strategies and when and why they might occur.

As a first attempt at longitudinal analysis it was decided to generate Networks twice during the first year of school as the children grew older. As the same notation was used each time it was possible to compare and contrast the networks and trace the children's strategies as they evolved or changed. As Bliss et al (1987) argue, networks are not a method of transferring 'soft' data into 'hard', or qualitative into quantitative, but are devised in order to introduce a greater degree of rigour into qualitative analysis. Using them at the start of encoding in this study allowed an initial identification and classification of young children's problem solving strategies towards developing an in depth categorisation of strategic choices. Then, by using networks at a second stage of the analysis, at the end of the reception year, the idea of frequency, consistency and change in strategies was considered.

3.4.3 Step Two: Beginning to Create a Taxonomy

The classification and characterisation of the strategies previously identified created the beginnings of a taxonomy. The network identified and classified a number of problem solving strategies and this was a base from which further analysis could take place. There was then an attempt to codify the transcripts with the initially identified strategies and, using these strategies as units of analysis, as much of the data as possible was coded. In this way the strategies were both generated by the data and used as units of analysis to yield new strategies or revise others, so refining and extending the taxonomy.

3.4.4 Step Three: The Revision of the Taxonomy

As the work progressed there was a gradual re-classification and re-characterisation of strategies to identify new pathways through the transcripts as a need was perceived to modify the taxonomy for different tasks using different materials, and groups of children, depending on age and experience in school. Those parts of the transcripts that could not be coded initially were then analysed across tasks and ages to attempt to identify and classify additional problem solving strategies. This then produced a new form of the taxonomy. With this new, revised taxonomy the transcripts were then re-analysed. This iterative process was then repeated until most of the transcripts had been analysed.

Once all the transcripts had been revised, it was considered that an exhaustive set of problem solving strategies had been found and the final taxonomy had been achieved for this set of transcripts. However, throughout the process an attempt was made to describe the strategies in the most general of terms so that the taxonomy might be applicable not only to the present work but to a possibly wider set of D&T activities.

3.4.5 Reliability Control

A reliability control was carried out with the newly revised set of strategies. The steps in the analysis described above were interrelated in a special way. The researcher worked with another to identify each of the units of analysis for step two, then tried to characterise and classify these in an initial taxonomy. She then taught this to the second analyst who used it on several other transcripts. The second analyst indicated strategies that corresponded to those in the taxonomy, or in some cases where the description of a strategy did not seem adequate. In other cases she indicated the parts of the transcript where there would appear to be no descriptor in the taxonomy to illustrate what was happening in the transcripts. Then the two analysts re-worked the taxonomy and tried the new strategies on more transcripts. In this way they worked together to find a general taxonomy comprised of one set of strategies. They worked alternately to focus on new pathways through the transcripts or subtleties within the strategies, as they concentrated on different tasks and materials or different age groups, so modifying the taxonomy as they attempted to apply it to a wider area of data. It was an iterative process and was very rich because the control on reliability gave good opportunities to identify those activities that were most strategic in terms of problem solving in the design and technology sessions, and to spot similarities and differences in classifications across the tasks.

3.5 Towards the Beginnings of a Taxonomy

The systemic networks in step one of the analysis had identified a number of problem solving strategies, but before proceeding to generate the taxonomy it was felt necessary to classify the tasks into more workable categories. To remind the reader the task matrix is repeated here (Table 1).

Table 1. Matrix of tasks, schools, ages and times of data collection

For three groups of children in each class: oldest, middle and youngest

Tasks	Class	Gorden Park Primary	Waterfields Infants
Greetings cards	YR	December 1992	December 1993
Invitations	YR	July 1993	
Portraits	YR		July 1994
Clay gifts	Y1	December 1993	December 1994
Buildings	Y1	July 1994	
Toys	Y1		July 1995
Moving vehicles	Y2	December 1994	
Puppets	Y2		December 1995
Shelters	Y2	July 1995	
Thank you cards	Y2		July 1996

3.5.1 Classifying the Tasks

In order to work systematically through the transcripts, confirming or developing the taxonomy, it was necessary to differentiate and group the tasks. Types of D&T task were grouped according to the materials and tools available for the children to tackle the problem. This was because it was noticed in the classroom that resources seemed to be a major initiator of young children's designing and making skills. Therefore, the tools and materials were used as a means of task classification as it was thought that, to a large extent, these led the children's strategies. Three types of task were identified: tasks using rigid collage materials and associated cutting and joining tools, a task using soft, malleable materials and shaping and smoothing tools, and tasks using hard materials and appropriate cutting and joining tools. Groups of children at Gorden Park and Waterfields schools, tackled certain tasks using tools and materials. Most children engaged in each category of task and sometimes did more than one task of a certain type. The task classification is presented below (Table 2).

Table 2. Resource Classification Matrix: Categorising tasks by resources.

Resources	Tools and Materials	Tasks
Category 1	Rigid and soft collage materials/ cutting and joining tools.	Greetings cards, Invitations, Portraits, Thank you cards.
Category 2	Soft malleable materials / shaping and smoothing tools.	Clay gifts
Category 3	Hard materials/ cutting and joining tools.	Buildings,Toys, Puppets, Vehicles, Shelters

Each category of task, classified according to tools and materials used, was analysed in an attempt to find possible similarities and differences in strategy repertoire for certain types of task depending on the resources. In other words, to find how general the taxonomy was for different categories of task. Comparisons were possible both within and across schools for groups of the same age engaged in the same task using the same category of resources.

3.5.2 Creating the Original Taxonomy

The purpose of this initial analysis was to create the original taxonomy, and looking generally at the strategies that emerged in tasks using different resources at different ages the tasks undertaken by the class of children in the data collection were compared. This analysis focused on the reception class at Gorden Park school where three groups of children in the same reception class took turns to make Greetings cards with category 1 resources. The transcripts of the three sessions were analysed and compared with each other to see if the same strategies emerged throughout the class. Then the transcripts from three groups engaged in a task using clay, a category 2 resource,were compared, from a Year 1 class at Waterfields School. Lastly three transcripts were compared, where the groups were using category 3 resources, to design and make rain forest shelters. This task was tackled by three groups from a Year 2 class at Gorden Park. This initial analysis represented groups of slightly different ages, but in the same classes, engaged in tasks using the same tools and materials. This was done for a different categories of resource in each year of Key Stage 1, in order to create the first version of the taxonomy (Table 3).

Table 3 Resource Analysis Matrix: Groups within schools using different resources.

Category	Task	Groups Compared	Class	Schools
1	Greetings Cards	Oldest/Mid/Youngest [6 children in each]	Year R	Gorden Park
2	Clay Gifts	Oldest/Mid/Youngest [6 children in each]	Year 1	Waterfields
3	Shelters	Oldest/Mid/Youngest [6 children in each]	Year 2	Gorden Park

3.6 Confirming the Taxonomy for Tasks and Resources

The purpose of the next analysis was to confirm the taxonomy for the same children in the same school, to see if the taxonomy was at all influenced by different resources and tasks. The main objective of these resource specific comparisons was to take each resource category in turn and ask whether the resources affected the groups response to different tasks in the same way. Were they the same for same age children in both schools, and could the taxonomy be developed to make it general enough to fit all categories of resource and types of task? In this way the taxonomy was a 'tool' used, not only to classify strategies, but also to explore and evolve itself, creating more generalisable versions as the data was analysed. In the final version the taxonomy was also a result that again could be used as a tool to analyse D&T activities outside this study.

The researcher first compared a sample of two specific strategies used by the same groups working with three different resources, within three different tasks. The oldest children at Waterfields designed and made Clay Gifts with malleable materials (category 2 resources), Toys with hard materials, (category 3) and then Thank you cards with flexible materials (category 1) (Table 4)

Table 4 Resource Specific Analysis: For a sample of 2 strategies within tasks, using 3 Categories of resources, same age children.

Resources	Class	Groups	Tasks
Malleable	Y1. Dec.	Oldest	Clay gifts
Hard	Y1.June	Oldest	Toys
Flexible :	Y2	Oldest	Thank you cards

3.6.1 Developing the Taxonomy for Different Resources

Then, in order develop the taxonomy further, from looking at two strategies it was necessary to do a deeper analysis of the possible influence of resources on all the strategies in the taxonomy for other groups of children. Therefore, the researcher looked at the use of same resource but in tasks across schools. Building on previous tasks analysed, the three previous tasks at Waterfields Infants were compared with tasks using the same resources at Gorden Park (Table 5a,b,c)

Table 5a Resource Specific Analysis: For Category 3, Hard Resources,across schools

Schools	Classes	Groups	Tasks
Gorden Park	Y2	Oldest	Moving Vehicles
Waterfields	Y1	Oldest	Toys

Table 5b Resource Specific Analysis: For Category 2, Malleable Resources, across schools

Gorden Park	Y1	Oldest	Clay Gifts
Waterfields	Y1	Oldest	Clay Gifts

Table 5c Resource Specific Analysis: For Category 1, Flexible Resources,across schools

Gorden Park	YR	Oldest	Portraits
Waterfields	Y2	Oldest	Thank you Cards

3.6.2 The Duration and Frequency of Children's Strategies

The next comparisons focused on the structure of the taxonomy and the sequence and frequency of children's strategies. These comparisons looked at the order in which the strategies occurred, their length and their frequency. An attempt was also made to consider other dimensions of the strategies such as pattern or possible overlap of strategies within the taxonomy. Tracing the same children's strategies as they grew older, the comparisons were made within schools, for consecutive tasks representing two categories of resources (Tables 6a,b)

Table 6a Age Related Comparison of Strategy Dimensions: Waterfields Infants-same children using same resources at 2 year interval.

Tasks	Category	Class	Groups
Portraits	1	YR	Oldest group only
Thankyou cards	1	Y2	Oldest group only

Table 6b Age Related Comparison of Strategy Dimensions: Gorden Park-same children using same resources at 1 year interval

Tasks	Category	Class	Groups
Buildings	3	Y1	Oldest group only
Shelters	3	now Y2	Oldest group only

3.7 Age Dependent Strategies

Having modified the taxonomy concerning task dependent strategies it was now possible to think about the extent to which group strategies were dependent on age. During the work so far the researcher had begun to notice similarities and differences in the strategies for tasks undertaken by the youngest and oldest groups of children, even within the same class. The focus was now on comparing the children's strategic activities as they grew older. The strategies from two tasks engaged in by the same groups of children over a period of time were compared. It was decided to look for strategic change in groups doing different tasks but to keep the materials constant. Groups were compared after a six month interval, one year interval, and two year interval.

3.7.1 Age Related Comparisons Over Time

The first comparisons focused on the two schools in turn. In each school the same children were tracked over a period of time using the same resources but doing two different tasks. First the strategies of three reception groups at Gorden Park, making Greetings Cards in December, were compared with the strategies they used the following June while making Invitations. Both tasks used collage materials. These same children were then compared when they were in Year 2, engaged in two tasks using hard materials and associated tools over a longer period of time (Tables 7a,b).

Children from the second school were then compared over eight months engaged in similar tasks to see if the same type of change had taken place in the two reception classes. Then the groups were compared doing two similar tasks with a one year interval (Tables 8 a,b.).

Table 7a Age Related Comparison: Gorden Park School - same children using same resources at 6 month interval.

Tasks	Class	Groups
Greetings Cards	Dec. YR	Oldest/Middle/Youngest
Invitations	July YR	Oldest/Middle/Youngest

Table 7b Age Related Comparison: Gorden Park School - same children using same resources at 1 year interval.

Tasks	Class	Groups
Buildings	Y1	Oldest/Middle/Youngest
Shelters	now Y2	Oldest/Middle/Youngest

Table 8a Age Related Comparison:
Waterfields Infants- same children using same resources at 2 years and 8 months interval.

Tasks	Class	Groups
Greetings Cards	Dec. YR	Oldest/ Middle/ Youngest
Thank you cards	July Y2	Oldest/Middle/Youngest

Table 8b Age Related Comparison:
Waterfields Infants- same children using same resources at 1 year interval.

Tasks	Class	Groups
Toys	Dec Y1	Oldest/Middle/Youngest
Puppets	July Y2	Oldest/Middle/Youngest

3.8 Advantages and Limitations of the Means of Analysis

It is important to explain more about the analysis and discuss some of its advantages and disadvantages. Both types of analysis, the networks and the taxonomy, were carried out on annotated transcripts of the D&T sessions so providing details not only of the children's verbal exchanges, but also of actions and physical interactions. The coding towards the taxonomy broke the transcripts down into episodes of strategic behaviour, often involving a number of children in the group, whereas the systemic network analysis focused on individual responses within the transcript, line by line. The former method was used on almost all the transcripts while the latter covered a sample at the end of each year group. Therefore, the two types of analysis seemed to complement each other in that they enabled enquiry encompassing each participant's contribution and the group's overall interaction.

There was a large amount of complex qualitative data in the form of audiotapes and related field notes and photographs. From the data some idea of frequency and development was required but also an understanding of the strategies from the children's perspective. Therefore, initially it was necessary to use some form of qualitative analysis which generated a relatively simple category scheme while capturing the essential subtlety and sensitivity of the children's transactions. The use of Systemic Networks seemed to fulfil both requirements. Bliss et al (ibid) argue that it 'works within defined categories but attempts to elaborate those categories to the point where enough of the individual essence of data is preserved' .

The creation of a taxonomy, and the work towards identifying and classifying variations in this taxonomy, enabled the long transcripts to be approached in units, representing distinct phases of a lesson where certain strategies were exhibited, and provided overviews of individual D&T lessons or blocks of lessons of different types. As these sets of strategies were always goal-oriented this gave clues to possible motivators that might trigger children's strategies. This supported aspects of the earlier networks. These clues could then be considered within the context of specific tasks using certain materials, or linked to an age range, so enabling further ideas about group strategy development to be formulated. The collaborative nature of the iterative process of analysis described above made for greater reliability, but a disadvantage of the analysis was its time consuming nature.

3.8.1 The Nature of Qualitative Methodology

The nature of qualitative methodology itself created a number of analytical problems. During the work of analysis the researcher brought to the process of categorising and coding her professional judgment concerning the meaning and relevance of aspects of the children's dialogue and interaction in the transcripts. In the course of this study the researcher's professional understanding had developed over many years of teaching in infant classrooms. Although this can be seen as advantageous it may also work to the detriment of the study as at this stage problems of over- immersion in the data can transpire, as the researcher becomes involved in identifying categories, highlighting and grouping actions and interactions, and writing code notes.

However, during this study the researcher was careful to try to avoid wild guesses about meaning and long-shot connections to other chunks of data in striving to reach beyond the obvious and limited scope of the dialogue. What appears significant within a transcript can differ from researcher to researcher and, although bias can never be eradicated, it is possible to strive for rigour in qualitative analysis.

3.8.2 Rigour and Reliability

Creativity is essential in the research process but throughout the analysis in this study the researcher attempted a rigorous and systematic approach to data reduction, display, conclusion drawing and verification. It soon became obvious that a central requirement in qualitative analysis is clear thinking on the part of the researcher, but Robson (1993) asserts that a number of problems may led to bias. These provide a useful checklist against which to measure the research methodology of the present study:

* Data overload: There are limitations on the amount of data that can be dealt with in one study. This is a common problem in longitudinal studies such as the present work, indeed at times, especially as the analysis progressed, there seemed a large number of transcripts and ideas to process and remember. The keeping of a research log during

observation and data collection, and a process diary during analysis was essential to track what was actually done. Another helpful strategy employed by the researcher was that of colour coding the transcripts, files of associated notes and photographs, according to school and year group so that information could be retrieved easily.

*First impressions: Sometimes there is a danger that early input makes a large impression so that subsequent revision is resisted. Again, the length of the data collection in the present study mitigates against this and although initial analysis was formative in interpretation of data, there has been much time and opportunity over the years of work to reanalyse and reinterpret results towards a greater depth of understanding.

*Information availability: Information that is difficult to obtain gets ignored. It is true to say that it was difficult to include in the present work design and technology tasks which used the complete range of resources. Indeed it is difficult to put a limit on the possible materials that might have been used by the children during design and technology problem solving. For example, the children were not given the opportunity to work with food as a resource in any of the tasks in the study. Similarly it was difficult to plan for the full range of problem solving situations in schools, although a serious attempt was made to include a representative cross-section of the type of D&T tasks usually used by teachers. Care was taken to be realistic in the choice of tasks chosen for the study in order to obtain results that would be useful to teachers, indeed in most of the sessions it was decided to use the design and technology work that the class teachers had already planned for their class in their schemes of work.

*Positive instances: There is a tendency to ignore information conflicting with hypotheses already held and to emphasise information that confirms them. The study tends to assume that when tackling D&T tasks young children do employ problem solving strategies, and it is taken for granted that these will become apparent through close observation and analysis. The study presumes that children act for a purpose or in response to a need during design and technology activities.

*Excessive confidence in one judgment or interpretation: In the present study, the raw data was classified and coded, on occasions, not only by the researcher but also by other experienced academics, colleagues and other research students, so that a code-consensus was arrived at towards greater reliability.

*Inconsistency: Repeated evaluations of the same data tend to differ. There is a real danger that this could be the case when analysing and re-analysing the transcripts from different perspectives, for example, age related and material related viewpoints. This must be borne in mind.

3.8.3 Validity and Recognisability

In addition to the above points, aspects of validity and recognisability were also considered in the analysis. Cohen and Manion (1990) identify two types of validity in observation-based research. They talk of *internal validity* relating to how we know that the results are genuine. This stems from fears that the researcher's judgment during naturalistic observation will be biased by being too close to the group studied. As discussed above, the researcher in the present study attempted to be constantly aware of the need to perceive the field with a fresh eye.

Cohen and Manion (ibid) also cite *external validity*, or how we know that the results of one piece of research are applicable to other situations. In the case of the present study the researcher was careful to make no claim to universal external validity as only two primary schools were used in the study. Moreover, these schools were both provincial, upper working class schools and fairly multi-cultural. The problem solving strategies identified in the study may therefore not be generalisable. This work by no means indicates that other children will necessarily exhibit similar strategies. Indeed it is important to bear in mind that there may be large sociocultural differences between same age children with respect to their problem solving skills. Much more work needs to be done. This is merely a starting point for further in-depth observation and classification of the strategies children use during practical problem solving.

Recognisability is one way of testing the reliability of not only the methodology but the outcomes of the research. Any system, means of analysis, or description used, needs to be recognisable in the sense that there is a level of acceptance and agreement about it. As indicated earlier, one way that this was done in the present study was for the researcher to be guided by a more experienced researcher sharing work on the analysis and seeking their opinion on the findings. Another way of testing for reliability is to feed back the findings to the respondents in the field. In this study it was sometimes possible to ask the children to reflect on the problem solving process after the session, but the children tended to focus on the products they had created rather than the process of the work. The class teachers, however, were keen to discuss both design and technology sessions and the progress of the research. This was reassuring as they seemed to see their own intuitive ideas reflected in the data, and it was gratifying to hear how behaviour and procedures identified in this study were often recognised by class teachers from their own teaching, both in design and technology and other areas of the primary curriculum.

3.8.4 Ethical Issues

A central issue that all researchers must address is the extent to which their activities are ethical. There is often a constant need for self-evaluation and self- regulation in dealing with the *moral dilemmas* and compromises the researcher has to face during field work. The present fieldwork began with problems associated with access. These revolved around how to gain fully informed consent from head teachers, staff, parents and children who had very little experience of the research process and often only a

partial understanding of design and technology education. In this case the focus of the study was explained at an open meeting at each school, and details of how the data was to be collected, and what roles the teachers and children were being asked to play in the research, were given and concerns shared.

An important issue was protecting the participants' *confidentiality*, particularly as audiotapes and photographs were being used. Parents were understandably interested in privacy and anonymity for their children and, although they were happy with the use of audiotape, it was decided that the use of the visual material would be limited and viewed only by the researcher, academic associates and the teachers and parents. The photographs of the children engaged in the design and technology tasks were enlarged and exhibited at school open evenings. In this way it was possible to provide some feedback to the school and parents, concerning the progress of the research.

The researcher's experience was that *reciprocity* was very important in researcher-researched relationships. Certainly the class teachers in this study saw the major benefit of involvement as an opportunity to observe design and technology sessions led by 'an expert' with their children in their classroom. While individual performance was not discussed, the children had pleasure in sharing their products with the class teacher after the session. For the teacher and researcher the discussions after the D&T sessions provided opportunities for regular feedback and re-negotiations of initial agreements and working procedures, but also brought to light some misconceptions of the researcher's role as observer rather than assessor of children's performance. This highlighted issues surrounding the participant confidentiality of the children themselves.

Chapter 4
The Creation of the Taxonomy

Introduction

The results of the study were of three kinds:

*The systemic networks identifying and classifying problem solving strategies. (Pilot Study, Appendix 3)

* The Taxonomy, as a result, characterising related goal-oriented strategies.

* Results relating to strategies by task, resources and age of children.

It is not possible here to provide full details of the complete results of the study so it has been decided to concentrate on the findings concerned with the creation and development of the taxonomy. The taxonomy represents group problem solving strategies in the form of coherent sets of activities that were intended by the children to fulfil a purpose, within the D&T task, contributing to the attainment of a goal or sub-goal. The final taxonomy attempts to represent the strategies of any of the groups of children undertaking any task, and using any resource. The first section of this chapter gives the final taxonomy (Table 9). Then it explains the children's strategies and presents two examples from the transcripts to illustrate each one.

4.1 Table 9 The Final Taxonomy

Personalisation.
Identification of Wants and Needs
Negotiation and Re-posing the Task
Focusing on Task, Tools and Materials
Practice and Planning
Identifying Difficulties
Talking Self through Problems
Tackling Obstacles
Panic and Persistence
Sharing and Cooperating
Showing and Evaluating

4.1.1 Description and Illustration of the Strategies.

Personalisation

Children sought to relate the task to themselves and their personal world. The aim of this strategy for the children seemed to be to learn through self-scaffold and by making links with past experiences. It appeared to aid them in concept building and enabled them to attempt to bridge the gap between 'school knowledge' and everyday experience or 'personal knowledge '.

R : Researcher C 1: First Child to Speak

Example: Invitations to a Teddy Bears' Picnic, YR, Oldest Group. Gorden Park Primary School. During the introduction the children initiated and contributed to a discussion of the task.

C1: I have a story book of when teddy bears go on a picnic, and a reading book.
C2: And I know a song
C3: Have you been to a teddy bears museum where you get all little foods and little plates.
R: No, I haven't. Have you?
C3: I haven't but my friend has.

Example: Victorian Toys, Y1, Oldest Group. Waterfields Infant school. After the introduction one child reflected on his personal knowledge of a similar task.

R: What will you make?
C: I' m going to make a Jack in the Box. My brother made a box ... it was in woodwork class, and first he did this bit, and he didn't stick it he got some nails and hammered.

Identification of Wants and Needs

This strategy helped children to think ahead concerning resources, people and places. Children used this strategy to recognise the resources they needed to carry out the task in terms of tools and materials and chose appropriately from the range available with varying degrees of confidence. They asked for alternatives according to their own requirements, priorities or personal taste. They also identified the demands of the problem in terms of the knowledge, skills and experience required to tackle the task, and requested individual or cooperative working arrangements.

Example: Greetings Cards, YR, Oldest Group. Gorden Park Primary School. The group spontaneously began by choosing either a product focus or materials for their cards.

R: What would you like to do?
C 1: An angel.
C 2: A Christmas tree.
C 3: I want to use the glitter.
C 4: So do I .....
C 5: Can I have some pink card?
C 1: I want a pink one.
C 6: I would like an orange one.
C 3: Pink! Pink! Do we fold them?

Example: Moving Vehicles, Y2, Middle Group, Gorden Park School. The group identified tools and materials they would need to make their vehicles. They began to think ahead.

C 1: I'm going to look at the tools to see what I'll need.
C 2: Will that glue stick?
C 3: We need a saw.
C 1: Here's a hammer.
C 4: I'll need a wheel.
C 3: One wheel?
C 4: No four, silly.
C 3: I'll need a hammer to knock the wheels on.
C 1: We might need elastic bands and plastic tube.
C 3: I've got four wobbly wheels.

Negotiation and Re-posing the Task

The purpose of this strategy for pupils was to explore with the teacher the boundaries of the task and seek to work within what was 'allowed' within the classroom culture, while satisfying their own wants, needs and interests. Children used this strategy to negotiate greater freedom to investigate and manipulate tools and materials, or to work alone or with a partner. As a result of negotiation they might alter or completely change or re-pose the problem solving task to suit themselves. Negotiation revolving around the overall task or sub-tasks within it was used for personal or group satisfaction and was concerned with sharing control.

Example: Thank you cards, Y2, Oldest Group. Waterfields Infant school. After the introduction to the task the group began to make their cards.

C1: You don't have to fold the card one way? (checking what's allowed)
R: No - Whatever way you want.
C2: You can fold it back and then the flaps and there - a paper aeroplane Thank you card. Now you can open it up in the middle. I can put the word open on both wings of the aeroplane card.(talking self through)
C3: Are we allowed to fold it any way we like?
C2: You can - yes you can.
C1: I'll fold it longways.
C4: I allowed to cut a pattern here and then put...?
R: Yes - be inventive.
C5: I know, I'm going to cut a hole there and when you look through the front it will say 'thank you'.

Example: Buildings, Y1, Middle Group, Gorden Park School. Before making, the group discussed the boundaries of the task and tried to extend them to include their own interests.

C1: Are we allowed to make a newsagents?
C2: No, that would be boring
C3: Wait a minute, wait a minute... a hideout I saw it on the news ...it's a dug-out but you can still live in it.
C4: A shoe shop?
R: A shoe shop, and I suppose you could make a dug-out but it's stretching the idea a bit.

Focusing on the Task or Tools and Materials

This strategy enabled pupils to concentrate for a time on either the purpose of the task itself, the tools, or the materials. Children used this strategy to make sense of or interpret the task. They related the task to previous knowledge or experience in other areas of the curriculum. They described and explained the task to themselves, specifying various components and expounding them in order to determine the exact nature of the problem. At times they concentrated fully on certain tools and how to manipulate them skilfully. They also focused on materials, exploring their properties, investigating their use, and employing conserving skills, in order to work with them in an appropriate and productive way. This strategy enabled children to continually clarify in detail what needed to be done and how to do it to solve the problem.

Example: Thank you cards, Y2, Youngest Group. Waterfields Infant School. The girls began to decorate their cards.

C1: I've got to put the glue on first - before the glitter now.
C2: Just get the right amount in the lid and very carefully shake.
C1: How are we going to get the spare glitter back in the tube.
C3: I know, I know.
C1: It is a bit hard.(trying to put it back with her fingers)
C3: See the glitter on the card, well fold the card and slide it in.

Example: Buildings, Y1, Oldest Group. Gorden Park Primary School. The boys investigated the use of the vice to saw wood.

C1: Mind your finger in that vice.
C2: Yeah, watch it.
C1: They are quite nasty.
C2: Look, he's squashing the wood.
C1: You might pull it all out of shape.
C3: How far up? (do I put the wood in the vice)
C1: Quite far.
C2: You've got to push it down, then it will go in.
C1: You can turn it any way.

Practice and Planning

The purpose of this practice strategy was to gain experience of manipulating or working with tools or materials. This strategy was sometimes re-visited many times throughout the activity, especially when new knowledge and skills were needed. Children could become so preoccupied with managing and manipulating the resources that practice, or self directed play with the resources, took precedence over progressing with the task itself.

Some children tended to become carried away with practising sawing wood, for example, and forgot the original task. Planning strategies took the form of verbal planning in role play or discussing what to do next; planning by placing materials together to see how they might look; and planning by making lists, drawings and diagrams on paper. Children seemed to perceive a strong association between practice and planning as they both concerned thinking ahead to later action. The relationship between children's understanding of practice and early forms of planning is demonstrated by older Key Stage 1 children.

Example: Vehicles,Y1, Middle Group. Gorden Park School. The group suggest a plan:

C1: Shall we draw it first? (draw their vehicle before making it)

C2: The pencils over here.

C3: You have to think what you're going to use.

C2: Like an egg box?

C4: A big piece of card.

C2: Some sticks.

C3: A cereal box.

C1: I'll need a rubber 'case I do it wrong.

C3: This is going to be a car (holding up a box)

C1: Can you draw the pictures of what you're using? (researcher nods)

C4: There's some orange, not red.

C5: Yellow's good.

C2: I've done the drawing and coloured it in. My tractors' going to move and be red and have windows and an exhaust pipe.

C3: Mine's going to be made by a cereal packet and have a door to open and a steering wheel to move.

Example: Thank you cards, Y2 Oldest Group. Waterfields Infant School. Some children used complex techniques in their planning.

R: What are the girls doing?

C1: Planning it out.

C2: We put a piece of white paper over the top of the card and drawn round the outline so as to make sure the plan is the same size as the card.

C1: I've folded my white paper at the bottom so it's the right size.

C3: This net will be good for sea plants...

C1: I'm not drawing it exactly. It's just my plan so I don't have to draw it absolutely with everything right.

C2: I'm going to do this part then cut some ribbon. I think I'd better glue it with strong glue - white's (strong white glue) better than this stuff from the tube.

C1: I'm going to change it slightly from the plan when I draw it on the card. You don't see the pattern and I want it bigger. Anyway I'm going to write something down the bottom in the space.

Identifying Difficulties

Children needed to devise strategies to respond to problems that occurred spontaneously during the lesson. They did this by unconsciously separating their reaction into types of strategy. As the children moved through the task, identifying difficulties was used as a strategy to pinpoint predicaments, then obstacle tackling strategies followed. There were many tricky problems concerning use or availability of resources. Children sometimes perceived difficulties in manipulating tools, sharing and conserving materials, or simply knowing what to do next.

Example: Moving Vehicles, Y2, Middle Group, Gorden Park School. While making their vehicles the group encountered various practical and organisational difficulties.

C1: Cutting this dowel is quite hard 'cause it rolls around.
C2: How can I keep the wheels on? (the vehicle)
C3: Where did I put that last wheel? It's gone. I was just going to put it on and it's vanished. (piece lost or used by another child)
C4: I've found one wheel.
C3: Oh thanks.

Example: Clay Gifts, Y2, Middle Group, Waterfields Infant School. Children using clay and smoothing and shaping tools encountered particular difficulties at the end of the task.

C1: I made a cave with an egg in it. Dinosaur egg. There! (shows peers)
C2: Oh, I can't get it off. (get clay model off the board)
C3: Can't get it off?
C2: Shouldn't have ....stuck it on.
C3: I can't get mine off either (trying to pull the model off the base)
C4: I can.
C5: I'm trying to get mine off now. (twists model slowly)

Tackling Obstacles

This entailed children working on the difficulties they had identified earlier. They became aware of problems or of making mistakes and began to use a range of ways of overcoming difficulties and mastering skills. These solutions included use of conservation and procedural skills and cooperative and help-seeking strategies, often directly related to saving resources such as glitter that were precious to the group. Young children also brought their experience of personalising a problem to bear by mentally calling up incidents of similar challenges at home. Together with strategies for identifying difficulties, children used this strategy to first specify the problem and then try to overcome it.

Example: Clay Gifts, Y1,Youngest Group, Gorden Park School. The children wondered

why the clay was becoming dry and unmanageable and discussed putting it back in its plastic bag to see if it would make it moist again. They did not think of using water.

C1: This clay is getting really hard. I can't do this.
C2: I think um we gotta put paper on it like that. (points to the plastic bag that the clay had been wrapped in)
C3: Well that'll get dried up in the bag.
C4: Put it in the bag for a long time.
C2: It will get all sticky again.
R: Do you think it will? If you put it in the bag?
C4: Yes.

Example: Self Portraits, YR, Youngest Group. Waterfields Infant school. The youngest children in the study were sometimes unsure of basic joining procedures such as putting the glue on the paper before the glitter.

C1: Can I have some glitter?
R: Where will you put it?
C1: I can put it anywhere.
C2: Can I put it on? (sprinkles it on without glue)
C3: Can I have the gold glitter, please?
C2: It's not on. When you shake the paper the glitter all comes down. (off)
R: What do you need to put on to the paper before the glitter?
C3: She forgot the glue.

Talking Self through Sub-tasks

During problem solving young children used self-directed speech as a strategy to accompany their own actions. This could be called externalised thinking. This thinking aloud took the form of self- scaffolding as the children were reflecting upon what they had done, alerting themselves to what they were doing, and telling themselves what to do next. This strategy can heighten self-awareness and aid planning.

Example: Greetings Cards, YR, Oldest Group. Gorden Park School. The children talked themselves through drawing and decorating angels.

C1: This is how you do a fairy ... I mean an angel.
C2: I'm drawing an angel... there and an arm. Oh, I've done it wrong...I did it wrong!
C3: There and there and now I'm decorating it ...with glitter ... ahhh ... glitter.

Example: Thank you cards, Y2, Youngest Group. Waterfields Infant School. A group decorate their cards and begin to write a message inside.

C1: I could put a bow at the bottom of my bunch of flowers to hold them together... How could I do it? I'm not very good at tying ribbon. I know I'll see if there's a bit already tied in the box..where....where, where...um ?

C2: Where's the glue?

C3: How do you write thank? t h a n k (sounding out word as he writes).

Sharing and Cooperating

Children used help-giving and help-seeking strategies to cope with problems. They gave advice and assistance with and without being asked for it. Then, sometimes there was a level of discord. This conflict also occurred when children needed to wait to use equipment, saw themselves in competition with others, or were perceived by the group to be 'copying' each other. But generally, they began to show their problem solving experience and use it to help their peers. This help concerned sharing their growing appreciation of which tools, materials and techniques were most appropriate in a given context. They also asked detailed questions concerning procedure and sought specific support both from peers and adults. Together with the previous strategy this allowed children to confidently use the knowledge and skills gained throughout the task to help each other to look critically at the quality of their product and modify or change it.

Example: Self Portraits,YR,Youngest Group. Waterfields Infant School. The group shared resource ideas and gave advice about safety procedures.

C1: Katie, do you want me to cut some of this for you? (pink felt)

C2: I'm going to have that material, not this.

C1: Can Katie put these little dots on?

R: Sequins, yes.

C1: Katie - these will be good for eyes.

C2: Little green dots for eyes....yes, thanks.

C3: Am I allowed the different coloured ones?

C2: These are my nose and these are my eyes.

C4: You could hurt someone if you carry scissors like that.

Example: Rain Forest Shelters,Y2, Oldest Group. Gorden Park School. Here the whole group worked together to share ideas about joining techniques and choice of materials.

C1: I need to do something with the triangles. (cardboard triangles)

C2: They are for gluing actually.

C3: Put it like this. (shows friend how to place card triangle across the corner to join two pieces of wood)

C1: Turned into kind of sellotape.

C3: You could use glue. (on the triangle)

C4: Oh good, there's sellotape here. (another child tries it with sellotape)

C5: But what can protect us from the sky? (in our shelter)

C6: Oh I know what I can use. (looking at the fabric bag)

C4: Take this. (offers felt)

C3: Take. (another child urges)

C6: Oh yes. (thanks)

Pretend Panic, and Persistence

These two strategies were used towards the end of a session. The crucial factor here is that the children realise that the lesson is coming to an end and there are two major routes open to them: either sudden panic or slow persistence. Tiredness and lack of concentration were two factors here and children sometimes had difficulty in sharing, squabbled over resources, or had small accidents with tools. Some children persisted with the task regardless, while some used a the role play drama of pretend panic to attract help and propel everyone into action. Friends and teachers could be crucial at this time in providing encouragement and helping to create a successful outcome.

Example: Invitations, YR, Oldest Group, Gorden Park School. Two girls loudly called attention to their difficulty in controlling the glitter and gained help from the group.

C1: Oh! Alison that's a bit too much.

C2: Oh! Sugar!, Oh my.. .sausages!.. (puts on too much glitter)

C3: Oh NO!... this glitter is all over the place!

C2: I didn't do it on purpose, did I?

C1: I know... all gone 'cos of you, but bad luck.

C3: Put it back in a big pile.

C4: I've got some, I've got some! (all rush to help)

C3: That can all go back. (in the tube)

Example: Buildings,Y1,Youngest Group,Gorden Park School. Towards the end of the session two children working together enlistied help from another to avoid disaster.

C1: How can I stop it falling down? (house wobbling)

C2: How do we stick that one like that? (create support for the roof)

C1: Oh my God! Oh my God! It's gone on the floor a little bit.

C3: Hold it up, Hold it up! (house collapsing)

C1: Quick! Quick!

C3: Phew... Done it!

R: You've done it. Good girl.

C2: Right. That needs to fit in there somewhere. (under the roof)

C3: Are you doing the front piece? (of the house)

C2: Yes. Can you stick it on? You've got it... stick it on quick.

Showing and Evaluating

This happened both during and at the end of the task. The children used these strategies during the activity to support each other and gain confidence. They were often reciprocated and may give children a feeling of growth and well-being or help them make judgments about their work. Children showed and sometimes deprecated their own work in progress in order to be reassured. These strategies served to consider progress, stimulate perseverance and inspire fresh ideas.The older children spontaneously paired or grouped themselves to evaluate each other's work. This was used as a means of reinforcing satisfaction or dissatisfaction with outcomes, enabling reflection on how the task was accomplished, and sharing problems and solutions amongst the group towards the testing and modification of products. Sometimes children's narrative took the form of a story as they acted out an imaginative scenario with their product.

Example: Greetings Cards, YR, Oldest Group, Gorden Park School. During the session the children offered their work in progress for evaluation by the group. Here the first child deprecated her own work, gaining reassurance and encouragement from her peers by this self-evaluation.

C1: That's my stupid one. (showing drawing)
C2: Let's have a look, Helen. That's good.
C3: That's jolly good.
C1: Everyone will say it's stupid.
C4: It's not!
C1: I'm in my baby chair and the toys are doing a dance and then the fairy says... (tells story of drawing to friends)
C5: Don't do your picture too big. (child gives general advice to group)
C6: Du, Da, Du, Da, Du, Da... BATMAN! (singing while drawing)
C4: I've done it.
C5: Look at this teddy, everyone.

Example: Victorian Toys, Y1, Oldest Group. Waterfields Infant School. Spontaneous peer showing and evaluating was most prominent in the middle and towards the end of the session when the children tested and modified their products. Here, Michael tested his aeroplane.

C1: Michael, one wing's bigger than the other ... I saw it when it was flying.
C2: Michael, you also sawed some of the wing off.
C1: Yeah ... one wing's longer than the other isn't it Peter?
C3: Shhh ... I can't think. I'm trying to think about the wing. It ... it can't fly on its own like this.
C4: I don't like this castle.

R: Why, what's wrong with your castle? You're castle's lovely . You've got your turrets ... and ...

C5: Err ... you need to do another window there don't you.

Conclusion

In this section an attempt has been made to illustrate the taxonomy by using examples of children's strategies from transcripts, but separating them is rather artificial as anyone reading the data could find examples of intermingling strategies. While most strategies are quite obvious and clear cut, some are extremely complex, exhibiting a number of strategy characteristics at once. To end this section here are some examples:

Example: Buildings, Y1, Youngest Group, Gorden Park School. Here the group focused on the task by brainstorming, from their personal experience outside school, concerning various types of building they might design and make. They concept build extending their understanding of what counts as a building. They also check what is allowed by the class teacher and negotiate realistic task options within which they might work. Here, focusing on the task, personalisation and negotiation are interwoven by the group.

C1: Does it have to be a house?

R: No ...?

C2: It could be another building.

R: Yes.

C3: Or a Big Ben?

R: Big Ben, yes, that's a building.

C1: The Statue of Liberty?

C4: A shed? My dad's got a shed.

C3: Sky scraper?

C5: A garage? Like one for our car.

C1: A castle?

C6: Church?

C5: Shop?

C6: Stables?

C4: Stable, yes, that's a building. Umm.

Example: Thank you cards, Y2, Youngest Group. Waterfields Infant School. At the end of the session the group entered into a complex discussion demonstrating focus on materials, conservation strategies and values, and planning strategies, as well as self structured play. This strategic interaction seemed designed to extend their own credit in school and their commercial knowledge outside.

C1: I've saved a tiny bit of gold here. (gold glitter in tube)

R: Thank you very much.

C2: That will help you remember that there should be gold glitter in there and you'll have to get some more.

C1: Yes, remember it was me.

C3: I'm a scientist. I'm using these chemicals in test tubes (glitter tubes).

C2: Can you buy glitter in square boxes?

C4: Well, actually you can buy glitter with glue already on in squeezy pens.

C1: I've got gold and silver at home.

4.2 Creating the Taxonomy

Introduction

Throughout the work there was always a double level of analysis in that it told us something about the children's strategies and the tasks, and helped modify the taxonomy. This section will begin to explain how the taxonomy was developed from the first analysis to the final version given in the first part of this chapter. It will detail the creation of the original taxonomy which was generated by analysing a broad range of D&T tasks to gain an overview of the data. Similarities and differences in group strategy profiles were sought across tasks, age range and schools to provide a first taxonomy at this time.

This original taxonomy was then developed and modified by systematically interrogating and questioning the data. Section three of this chapter describes the first development of the taxonomy, focusing on the resources used during the D&T tasks. Here questions were asked about how general the taxonomy was regarding tools and materials.

Section four explains the further development of the taxonomy, this time focusing on possible strategy change as the children grew older. Here questions were asked as to whether it was possible to use the same general taxonomy at different stages of the children's development or whether it would need to be modified according to their age. The final development of the taxonomy, detailed in section five of this chapter, focuses on the sequence, frequency and duration of children's strategies. It posed questions concerning the structure and dimensions of the taxonomy.

4.2.1 The Original Taxonomy: Focus on the Tasks

A first attempt at creating a taxonomy of children's problem solving strategies was made through analysing a broad range of children's D&T tasks in the study. These activities revealed the strategies of groups of children in different schools, throughout Key Stage 1, engaged in different types of task. In order to create this original taxonomy it was necessary to sample different ages, resources and tasks across the data to see if the taxonomy had validity. Sampling the limits of the data across the variables allowed us both to get a first taxonomy, and to use it as an instrument with which to work. With this instrument it was then possible to go back systematically through the data modifying the original taxonomy.

Three general categories of task were used in this first sweep. These were

represented by Greetings Cards, based on soft and flexible collage materials and associated cutting and joining tools, Clay Gifts using malleable clay and shaping and smoothing tools, and designing and making Rain Forest Shelters, made with hard and resistant materials and related tools. In analysing this sample of tasks similarities and differences in children's strategic activities were sought. The question was asked: Is there a set of strategies common to all groups? Is there a general taxonomy?

It is worth mentioning again here that because the reception aged children were admitted to school twice a year according to age and were taught in three age groups in the reception class in both schools in the study, the tasks were done using these groups. Because the work started in this way in the reception class, the groups were retained throughout the study, in Year 1 and Year 2, so that in each class the D&T tasks were carried out with the oldest, the middle and the youngest group.

4.2.2 The Strategic Nature of Children's Interaction

Throughout the analysis, but particularly at the beginning in order to generate the first results, questions were constantly being asked concerning the nature of the children's action and interaction. Interrogation of the data revolved around questions such as:

* Can we justify that a specific short activity, within the task, constitutes a strategy which happened by design, and is not accidental behaviour?

* Can the group be said to employ collective strategies? Are they acting purposefully in response to a shared problem, want or need?

* Do children's strategies have an outcome? Are they effective in tackling the problem or meeting the need?

In this way there was a constant search for the specific role of each sub-set of activity within a D&T session, and what this activity achieved for the group in terms of the goals that emerged. Looking in detail at what could be ascertained about the purpose of the children's actions helped to form a more intimate understanding of their motivation within the task, and made their problems, wants and needs more real to the researcher. It was decided to begin the analysis by looking closely at the transcript of Helen, Kim, Orin, Alison, Chris, and Nikki, one group of reception children, making Greetings cards. (Appendix 1) In this first result the children's names are included in order to give a general feel for the makeup of the group. However, it is important to stress that the focus of the research was not on individual but group interaction, since cooperative strategies are emphasised as a major aspect of design and technology education. Therefore, the remaining results in this chapter have a group rather than an individual focus. The following set of results are in response to the question: Is the group acting and interacting in a strategic way to solve problems or needs, and if so what is the effect of these strategies, or what did the group achieve? The purpose and outcome of their action was charted. (Tables 10a, b)

Table 10a The Strategic Nature Of Children's Interaction: For Greetings Cards, YR, Gorden Park Primary School

Problem/Need	Strategy	Outcome
The problem for the children was to answer the researcher's question 'What kind of cards might you make in December?'	**Personalisation** H: Birthday cards: O: Christmas cards C: 'cause it's Christmas. H: And it's my dad's birthday.	The group brainstormed types of Greetings cards from their experience at home towards giving the answer to her question that the researcher would want.
The problem was to understand what making a Christmas card entails and to help each other make sense of the proposed task and think about what they might be asked to do.	**Focus on task** C: I made a card before K: First we got some card and we drawed a picture on it and we.... N: We coloured it in O: We put sticky on it	Chris reflected on a previous task of a similar nature. This prompted the group to share clues as to how they might approach the task ahead and make explicit their agreed order of procedure when designing and making a Greetings card.
The children needed to choose a focus for their work, announce it to each other and the teacher so that they could start immediately.	**Identification of needs** H: I will draw an angel C: A teddy bear. A: A Christmas tree. K: I want to use the glitter. O: So do I	This clarified the main priorities of each member of the group both in creating a product and experiencing the materials. In announcing these to the group and the researcher they checked by the response that their chosen focus was appropriate for the task.
To make sure they understood the boundaries of the task, what was 'allowed' in school, and if they could take the cards home.	**Negotiation** C: And when we've made our cards what will we do with them? O: Are we allowed to make two?	Chris and Orin acted as spokesmen for the group, clarified the purpose of the product from the researcher's point of view and put forward the children's interests while testing out the group's persuasive power.
To share, handle and enjoy and investigate the materials, and find out what the resources could do in general and specifically how they might enhance the children's cards.	**Focus on materials** C: Can I have only a little bit because of the other children.(tinsel) O: Can I have some of this string?(picks up the roll of ribbon and looks through the hole) K: This one or this one?(tries sequins on her work) C: er...ahhh K: What do you think? A: One of these .yes. N : Thats nice.	The group demonstrate the advantage of working together to choose and use resources. Chris verbalises his awareness of the scarcity and value of some materials and the need to conserve and share them within the group. Orin investigates the ribbon but is unsure of its name, while Kim chooses sequins with the help of Alison and Nikki .

4.2.3 The Purpose of Children's Action and Interaction

The first task of the study was for reception class children to design and make Greetings cards. It was planned by the class teacher as part of the Christmas celebrations in school. The researcher introduced the task by using a box of commercially produced cards as a short focused evaluative activity before the children designed and made their own cards. The six members of the oldest reception group seemed to exhibit goal oriented interaction which formed the introductory strategies of *personalisation, focusing on the task, and negotiation.*

At the beginning of this session the pupils used their strategies to explore the boundaries set by the task. Faced with the researcher's questions in the introductory activity the children attempted to relate to the task by *personalising* it and calling up from their own experience similar instances of card making. The group quickly *focused on the task* itself and its use in relation to both home and school

K: So when we've made our Christmas cards what shall we do with them?
O: Hang them on the wall?
A: No, leave them to dry.
C: Take them home?
O: Put them on the Christmas tree.
C: Give it to people.
O: I could give it to my mum.
C: Your gran?
H: I know, our nanny.

They reflected upon the design and make process from their previous experience, demonstrating their procedural knowledge. By making sure that they understood what was 'allowed', they strove to make sense of the concept of 'a Christmas card' as seen by the teacher and society and *negotiated* the number of cards they could make and what might be considered appropriate as an illustration.

H: What can you draw on Christmas cards? A Christmas tree?
C: Birds.
R: Any birds?
O: Only robins.
H: Angels fly.

This led the group to *focus on the task* again through examining commercial Christmas cards in order to explore the most appropriate illustrations to use on their own cards.

H: Oh look, a teddy bear. (children looked at the commercial cards)

A: That's a star. That's my one. idea to use)

O: Oh, food on it. (surprised to find this appropriate)

K: That's my idea. That's a dog.

O: Oh God, you can put God on it. (puzzled)

H: That's a new born Jesus.

C: Ahhhhh!

K: And Jesus is God.

Interestingly, however, all this was perceived as a 'waste of time' as the children wanted to 'get on' and make.

R: So there's lots of ideas.

N: We're wasting our time.

R: You think we're wasting our time?

A: Yes, let's get on!

The collective problem or need of this five-year-old group was to make sense of the task of making a Christmas card by finding out all they could about such products, so that they could design and make successfully. In this concept-building they needed to know what the cards looked like, how they are made and what to do with them afterwards. They used strategies to satisfy this need by drawing on their own experience, exemplars in the form of commercial cards, and questions to the researcher and their peers. They had the problem of balancing their own agenda to 'get on' with the making, with the need to gather enough information about Christmas cards to be sure to make a card that was worthy of taking home. They asked to make two cards, to be sure of success, and were satisfied with their negotiation when the researcher replied,

R: Let's make one first and then we'll see if we have some more time.

A: Good.

It appears that these were collective strategies where the members of the group acted in consensus to collaborate in each interaction. The group prompted the end of the introduction to the task by the researcher, by identifying their own wants and needs through stating their wish to start making. By their strategic interaction they had agreed two main objectives: to create a product with a certain illustration, and to experience a certain material. They had also demonstrated and shared some understanding of the order of the work and laid claim to the finished products. They began the hands-on part of the session by introducing other strategies (Table 10b).

Table 10b The Strategic Nature Of Children's Interaction: For Greetings Cards, YR, Gorden Park Primary School

Problem/Need	Strategy	Outcome
The children need to know the names of the various materials in order to gain equal access to them and enjoy their use. They also want to produce a pleasing Greetings card so begin to think and plan ahead carefully and Practice before cutting and joining.	**Practice/planning** R:Isthat glitter too?(child tries tinsel on her card in various positions and on her friend's hair too) A: I don't know. K: It's tinsel. C: You can make decorations like little wings. Can we use some?	The group supported each other in self structured 'play' with resources. Alison Practiced placing the tinsel in different contexts and planned in her head where it might look best on her card. They shared vocabulary and ideas about this. Kim named the tinsel and Chris suggested Alison should use it to make wings for her angel, and also checked that it was for general use.
They had definite preferences for coloured card but knew that supply was limited. They were unsure what skills the researcher expected but knew that she did not know where the pencils were and that they might squabble over them.	**Identifying needs** O: I would like orange. K: Pink! Pink!..... N: Do we need to fold the card? O: What about a pencil? A: Put them in the middle . Everybody can reach them there.	Everyone was satisfied with their choice . They knew that they should start by folding and gathered other resources to share without fuss.
The children needed to draw outlines on the front of their cards but could not always do this easily. They adopted strategies to tackle the problem such as talking themselves through or looking to a friend's for an example.	**Tackling obstacles/ Talking to self** A: This is how you do a fairy ... I mean an angel. H: I'm drawing an angel... there and an arm ...oh I've done it wrong....I did it wrong! N: There and there and now I'm decorating it with glitter ..... ahhh	The group tackled difficulties in representing an angel by sharing their work and talking to themselves. Alison showed her work which prompted Helen's attempt to draw an angel on the front of her card. She described her action as she did it and making a mistake she looked at her friend's drawing for help. Nikki also described present action and his feelings of satisfaction and fulfilment at using the glitter.
The group needed some praise and feedback to encourage them to persevere. They prompted this by offering their cards for appreciation at intervals in the session	**Showing/evaluating** K: It's too small. He can't put decorations on it if it's too small A: Look, my angel. I've done my angel. C: That's good. O: Don't look like one .	Showing prompted shared evaluation.Kim made a valid comment on Nikki's work early enough in the session for him to act upon it, while Alison received differing opinions from the group about the quality of her angel.

These five-year-olds often *talked themselves through* a sub-task or skill especially where they had *identified difficulties* as in this instance where Helen has attempted to draw an angel on the front of her card and went wrong. To the group *identifying difficulties* appeared to be a problem solving strategy that had a help-seeking effect, and good advice and practical help is given by Kim and Chris :

H: Oh, I've done it wrong.
K: Rub it out.
H: Rub it out. (talking to self)
C: Anyone got the rubber?

The use of glue was problematic for these young children. They put too much glue on the card or often none at all, and sometimes glue was put on top of the material to be stuck. This caused general consternation but peer support included offers of wiping it off, a new piece of card, and warnings before attempting to join materials.

N: Wipe it.
A: Anyone got a tissue?
N: I know you can get a new one. (child offering friend a new piece of card)

Sharing and cooperating was used very early to tackle problems. After his own mistake Chris advised Nikki 'Put the glue on first'. These practical problems sometimes led to giving up on a product or process. Giving up or changing direction appeared to be a very useful strategy at this age. Helen discarded her green paper as it has made her 'all sticky'. Earlier she had so much trouble drawing an angel that she gave up in favour of a Christmas tree:

H: Angels are too hard for me. (child gives up trying to draw an angel and starts to draw a Christmas tree instead).
A: They're not too hard for me.
N: You just need to get used to them, that's all

Practice was closely associated with *focusing on materials* and this incorporated conserving skills, demonstrating the value that the children put upon certain resources such as glitter.

A: Something's missing here.
R: Yes, what do you need?

A: The lid so the glitter's not wasted. (plastic lid for glitter tube)
N: Yes, pick it up and put it in. I've got a good idea .... I think that if you put something here .... you can put the glitter in it and pour it back in the tube.
R: Oh I see you brush it into the fold of the paper towel. That's a good idea. Will you do that?
(Child making a funnel for glitter with paper towel and pouring it back into the tube.)

Showing and evaluating was used as a strategy throughout the activity for the reception children. Individuals offered work to the group for either appreciation or advice concerning materials, skills, or the presentation of the product itself. Evaluation of Alison's angel gave her feedback on which she acted to modify her drawing by changing the angel's wand into a handbag.

N: Look's like she's holding a flower or an arrow.(remarks on Alison's angel)
A: Yes, a flower.
H: Yes, or a handbag.
A: Mmmm, a handbag. (changes angel's wand to a handbag)

In this way the children could be seen to collectively identify problems, wants or needs, use strategies to tackle them and achieve a successful outcome. In their terms young children's strategies often seem to work well for them.

4.3 Common Features of Children's Strategies

4.3.1 Three Groups in the Same Reception Class

Having looked at one reception group's interactions, the analysis then questioned the extent to which the other reception groups used strategies, the location of these, and how far certain strategies were collaborative. The focus moved from one group of reception children in the class to three groups. Firstly, looking at three groups of children in the same class doing the same task of making Greetings cards, the question was asked: Are the children in the groups using the same type of strategies at similar times in the session, and if so could these strategies be said to form a taxonomy of group problem solving strategies? In order to compare the activities of the three groups it was asked: What are the common features of these strategies? The groups were compared regarding frequency of strategy use, and location of strategies, either during the introduction to the task, the beginning of designing and making, part way through the activity, or towards the end of the D&T session. The number of childrenengaged in each strategy , from each group of six, were also compared (Table 11a).

Table 11a. Common features of children's strategies: in 3 groups designing and making Greetingss cards in YR of Gorden Park Primary school

Strategy	Instances			Location	Contributors		
	Oldest/ Mid/Young			Oldest /Mid /Young	Oldest/ Mid/Youngest		
Personalisation	10	12	13	Introduction to task	All	All	All
Focus on task	10	8	15	Introduction to task	4	All	All
Identification wants/needs	7	10	6	Beginning of / Intro Task	All	All	All
Negotiation	3	1	0	Introduction —	3	1	0
Focus on materials	9	8	6	Throughout the task	All	All	All
Practice/ planning	3	2	0	Introduction —	3	2	0
Identifying difficulties	5	4	4	Middle of task	All	4	3
Tackling obstacles	5	4	3	Middle of task	All	All	All
Talking self through	10	13	15	Throughout the task	All	All	All
Pretend panic and persistence	2	0	1	end — Towards end	4	0	3
Sharing and cooperating	8	5	3	Middle and end	All	4	3
Showing and Evaluating	5	1	4	Throughout task	3	1	4

The comparisons showed that, although most strategies were engaged in to some extent by all the groups, certain strategies were missing in the youngest and middle age group. These were *practice and planning*, and *negotiation*, where noticeably fewer instances occurred, and none in the youngest group, and *pretend, panic and persistence* where least instances across the groups occurred, and none, in the middle years. This may be because all three strategies seem to require some degree of experience in both designing and making and the social and cultural context of school, where children interact with adults. These strategies entail understanding the need to think ahead to manipulate not only resources but powerful people.

Showing and evaluating showed a fairly small number of instances, with few children contributing, especially in the middle age group. This strategy also requires a degree of maturity, particularly where the shift from spontaneous showing to making evaluative judgments is required, at around Year 1. Here children must be reflective and think about what they did, and not only about the present and what to do next.

At the other end of the scale, three strategies showed the highest level of frequency, and all children in the groups used them at some time during the activity. These were *personalisation, talking self through* and *focusing on the task. Personalisation* showed a slight variation in the instances of strategies across age groups which could be due to the apparent lack of confidence of the youngest group in the class who had recently started school. They may have felt the need to make sense of the tasks in school by relating them more closely to familiar, personal contexts.

However, the groups showed a marked difference in *talking to self* as a strategy within the reception year. There was a decline in the ratio 3:2 from the youngest to the oldest children, perhaps reflecting the decrease in egocentric speech. Conversely, there was an increase in the ratio 3:2 of groups *focusing on materials*. Strangely, this trend is reversed in *focusing on the task*. Perhaps the youngest group focused less on materials and more on the task, since they seemed to have a problem understanding the function of Christmas cards, and holding the task in their heads throughout the session. At one point two of the group wanted to draw elephants on their Christmas cards, completely forgetting the illustrative conventions that had been discussed in the introduction.

A lack of confidence to choose and verbalise their choices is shown by the youngest group in *identification of needs.* Here, while the middle group chose coloured card and other resources with assurance, the younger children adopted a more watching and waiting attitude, they wanted 'just a little piece of card' and were unsure if choice was 'allowed'. The oldest group chose without comment except when in *negotiation* with the teacher and, as mentioned previously, had enough experience of working with the resources to begin to employ *planning strategies* concerning future cooperation:

K: I can't do it. Help, I didn't have any glue that's why. (sequins won't stick to card)

N: Put the glue on there and there.

K: If I put the glue, you can put them on. (sequins)

N: Yes, and then I will do it for you when you want a sequin.

K: Let's remember that.

All groups engaged in play at the reception age and this exclusively involved investigating the materials, and accounted for the large number of strategic activities focusing on materials. Through play, the children explored the properties of glitter, sequins, tinsel and some balloons, which gave scope for scientific investigation, and provided evidence of growing instances of *sharing and cooperative* strategies and early peer tutoring:

A: You've got to blow really hard, Helen. (into the balloon)

N: You've got to hold it there.

A: Well get it like that ..... that's right. (child helping friend by holding end of balloon firmly and putting it to her mouth)

H: Huh, Huh, Huh....(child taking huge gulps of air before she begins to blow up the balloon)

A: You're doing it right.

N: Go on, go on, go on, go on ....

A: Keep on blowing!

N: Really hard. (child successfully blowing up balloon)

A: It will go again if you let go of it. You've got to be careful cos they do such a thing as shoot. (across the classroom as air escapes)

These cooperative strategies were seen to substantially increase in number for the oldest group in the class and are evidence of children working spontaneously in twos or threes to tackle a problem.

4.3.2. Three Groups in the Same Year 1 Class.

The second comparison looked at children in the same class doing the same task of making Clay gifts, again the same question was asked concerning the existence of common strategies within the taxonomy as it was refined and the interrelationship of the strategies began to be better understood. The common features of these strategies were again compared regarding the instances, location and number of contributors within each group. Again the results were logged on a grid so that they could be compared across the three groups (Table 11b).

Table 11b. Common features of children's strategies: in 3 groups of Y1, designing and making Clay Gifts, at Waterfields Infant school

Strategy	**Instances** Oldest/ Mid/Young			**Location** Oldest /Mid /Young	**Contributors** Oldest/ Mid/Youngest		
Personalisation	5	6	8	Introduction	4	5	All
Focus on task	4	6	8	Beginning of task	4	All	All
Identification wants/needs	10	8	7	Beginning of task	All	All	All
Negotiation	6	3	2	Introduction and beginning of task	4	2	1
Focus on materials	18	16	14	Throughout the task	All	All	All
Practice/ planning	4	3	1	Beginning of task	3	2	1
Identifying difficulties	11	9	8	Middle of task	All	All	All
Tackling obstacles	11	7	6	Middle of task	All	All	All
Talking self through	3	6	8	Middle / Through out	3	All	All
Pretend panic and persistence	1	1	1	Towards the end	4	2	3
Sharing and cooperating	6	7	7	Middle and end	All	All	All
Showing and Evaluating	8	6	9	Mid / Throughout End	All	All	All

For this Year 1 class the group comparisons showed that the same type of strategies were used across the three groups of six children, when they were engaged in the very different task of making clay gifts, but that the instances of these strategies were very different across the groups. For example, the instances of *personalisation* varied from group to group and were located mainly in the introduction, as with reception aged groups. The oldest Year 1 group demonstrated their understanding of what happened in school, and the group personalised the task, relating it to their previous experience with clay, as follows:

C1: I bet the works about snow today. (it was snowing outside)
R: Yes it could be about snow but I'll give you a clue. (looking around the classroom)
C2: It's clay. (looking for clues and seeing the material on a side table)
R: It's clay, yes.
C3: We did this last year, didn't we?
R: Did you?
C2: We made a model of ourselves.
R: Ah.
C4: We can play with it.
C2: Have you got clay at home?
C5: My sister's got a whole bag full of it from Christmas.

The Year 1 groups *focused on materials* as a strategy, and all children were involved in this strategy throughout the task. This strategy showed by far the highest level of frequency in this Year 1 class. The middle group spent some time exploring the properties of the clay and comparing it to chocolate ice-cream, while the oldest group described it as 'all squishy', 'all wet and sticky' and 'it feels very slimy'. Indeed all groups tended to become so absorbed in the material itself that they needed a reminder from the researcher of the aim of the activity. This led the Year 1 groups to *focus on the task itself* and to satisfy their own interests while still fulfilling the teacher's agenda.

R: You need to make a Christmas present for someone, a gift.
C1: Pottery.
C2: Can we make a teapot for our mum?
R: Yes, you could, what else is made out of clay?
C3: Mug for my dad.
R: Mugs are made out of clay, yes. Anything else?
C4: Little bunnies.
R: You could make a little bunny out of clay...
C5: Are planets made out of clay, some planets?
C3: Are they? Do you think so? Hey that's a good idea.
C5: Make a planet and a spaceship.

C1: I want to make a pot. To put pencils in it.

C6: An aeroplane pot.

R: Mm?

C4: A bird. My Nan likes birds.

R: A bird.

C3: Football ground for my brother.

C2: I knew you would say something about football.

C3: Or a rugby ground.

It may also prove an indication of older children's greater confidence in taking control of the task and having more experience of the pedagogic system, that instances of *negotiation* increased threefold from the youngest to the oldest Year 1 group. This group began to negotiate with the researcher about what they were allowed to make:

C1: Can we make anything at all?

R: Well, what gift would you like to make?

C2: We can make anything we like, can we?

C3: I'm going to make a football ground.

C4: No, you make the bricks out of clay don't you? So you could make a school, you could make a building.

C5: Could you make a boat?

Compared with other strategies, however, there were relatively few instances of *Negotiation* but these increased dramatically throughout the year. This was also the case for *Practice and planning* where there was an increase in occurrence from the youngest group to the oldest Year 1. Practice in the Year 1 groups working with clay is illustrated by the following passage where the children verbalise the strong association between practice and play :

C1: Can we start?

C2: Get going?

C3: Have you got any tools that we could use to play? (Practice) We could see how to do it.

C4: Yeah, have a go before we start. Then we'll know how to use them 'cos I want to decorate mine.

R: I have brought some tools. (producing modelling tools)

C3: I'll need that one.

C4: See what it can do first of all, though. See what you want to do with it first of all.

While *talking self through* again showed a marked decline from the youngest to the oldest group, the strategy was closely associated with *identifying difficulties* and *tackling obstacles*. The instances of these were understandably similar group for group in the same class,as one follows from the other, but older children seemed able to engage in a much greater number of both. *Identifying difficulties* related to materials, people and places and talking themselves through helped the children to manage their difficulty with the consistency of the material. Here the youngest group were encountering difficulties and reasoning with themselves. They described their actions graphically as they manipulated the clay:

C1: I need to cut it. It's too stiff to break with my hands.
C2: I need some water on my hands now because it's going dry.
C1: Just a tiny bit.
C3: I need that water a tiny bit too.
C1: Can I have a tiny bit of water?
R: What would happen if you put too much on?
C4: It would...
C3: Break.
C2: Go soggy.
C4: It sticks to the board.
C5: And it goes solid too.
R: Goes solid, yes.
C6: And if you take it off and it's on the newspaper you can actually move it.
C1: Yeah.
C3: If it's stuck on the board you just have to get a knife to cut it under.
C1: Yeah, you just have to cut it.

Pretend panic and persistence remained fairly constant throughout all groups. This appeared to be a strategy used by a limited number of group members, while *sharing and cooperating* and *showing and evaluating* were used by all children at some time during the session, and they tended to increase as the groups got older. *Sharing and cooperating* revolved around shared problems and children helping each other to look critically at process and product. Changing course or direction or giving up on a product was also used as a strategy here, and the children showed how they valued the clay by using up each small piece.

C1: Will mine fall apart?
C2: If you cover up all the little gaps, it could really count as a mug.
R: Yes, are you going to do it with your fingers?

C3: No, Timothy, that will get dirt into your mouth. Could be really really dangerous, couldn't it? (girl tells Tim, who uses saliva to smooth model)
C1: No, 'cos when it gets stone hard you have to wash it and then....
C4: Yes, I think I've got too much clay. Look.
C2: You just make little decorations with the pieces.
C5: I think it's a bit too big, cos look. (shows friend her teapot lid)
C6: Be best to try it on.
C4: Put it next to the pot.

These groups also discussed detailed questions concerning procedure such as ' When the model's dry can we paint it?' but they seemed to have a good idea of the order in which to proceed. The oldest group using clay in Year 1 moved from evaluation of product to process easily across the session. Here three children engage in spontaneous showing, self-evaluation, and evaluation of the work of their peers, during making:

C1: Do you like mine?
C2: I have to make the handle now.
C1: Like mine?
C2: Whoops, it's slippery.
C1: This is supposed to be the steerer of the boat.
C3: Here's a little canal boat 'cos there's the thing to steer it.
C4: It's stuck.
C5: I think you need a little building on it.
C3: That's what they normally have.
C1: I'm just gonna do a building.
C2: I think mine's really really too wet.
C6: Ugh!

4.3.3 Three Groups in the Same Year 2 Class

The third comparison was of three Year 2 groups making Rain Forest Shelters. This task was planned by the class teacher as part of a cross-curricular topic. The same question was asked concerning the existence of common strategies within the taxonomy and their relationship to each other. The common features of these strategies were again compared regarding the instances, location and number of contributors within each group. Again the results were logged on a grid so that they could be compared across the three groups (Table 11c).

Table 11c. Common features of children's strategies: in 3 groups Y2 designing and making Rain Forest Shelters at Gorden Park School

Strategy	Instances Oldest/ Mid/Young			Location Oldest /Mid /Young	Contributors Oldest/ Mid/Youngest		
Personalisation	1	0	2	Middle of task	2	0	1
Focus on task	9	7	8	Throughout	All	All	All
Identification wants/needs	12	11	10	Beginning and Middle	All	All	All
Negotiation	9	8	8	Into and beginning	5	4	5
Focus on materials	14	11	12	Middle of task	All	All	All
Practice/ planning	5	4	3	Beginning and Middle	4	4	3
Identifying difficulties	14	14	12	Middle of task	All	All	All
Tackling obstacles	13	12	10	Middle of task	All	All	All
Talking self through	1	0	2	Throughout	1	0	2
Pretend panic and persistence	2	1	1	Towards the end	4	3	2
Sharing and cooperating	18	17	19	Throughout	All	All	All
Showing and Evaluating	11	9	9	Throughout	All	All	All

The comparisons showed that the three groups of six Year 2 children, when they engaged in making shelters, again used very similar types of strategies. However, the instances of these strategies were fairly uniform across the three Year 2 groups. For example the instances of direct *personalisation* happened rarely now from group to group as did the strategy of *talking self through* ; it was used by only one or two children in the group and in the middle of the session. However, at the beginning of the session the children *focused on the task* immediately as they tried to imagine themselves making a shelter in a rain forest.

C1: I went to the New Forest.
C2: Well, I'd like to live in a rain forest.
C3: I would too.
R: How would you live in a rain forest?
C2: In a tree.
C3: Like a monkey.
C4: A camp.
R: You would make a camp.
C2: I would. I would make a tree house.
C5: I would make a tree house.
C6: I'd make a tree house as well.
C4: I'd make a house out of sticks.
C1: I would, um, use some wood and glue it together and bring some...

Conversely *sharing and cooperating* was a very high profile strategy in all three Year 2 groups. It seemed apparent that older children were able to confidently use their wider experience, knowledge and skills to help each other. They seemed accustomed to working in twos but here one pair of children help another pair although they are unsure if working in fours is really 'allowed'.

C1: How can you make a sun shade?
C2: Look. (shows cardboard wheel)
C1: Circle of cardboard.
C3: We're trying to make a sun umbrella. (to another pair)
C2: I know.
C1: I can't get this down, look.
C2: I've got a circle and I've got the scissors.
C1: I can cut mine.
C2: Sort of, sort of... (child demonstrates cutting and bending circle to form umbrella shape)
C4: There they are. (points to card wheels)
C1: I need a big one.
C4: You could have this tiny one for a little child or something.

C3: I want this to be a lamp next to the bed.

C4: Oh I see, you're going to make a lamp anyway.

C2: Do you think we should be working together, me and you?

C1: This really won't stick down. I've tried and tried.

C2: Well, we could...

C1: Can I borrow the glue?

C4: We'll show you what to do.

Negotiation strategies were fairly widely used across the three Year 2 groups and they also revolved around working together:

C1: Can you either do it alone or you can do it with a friend ? (holds friends hand)

C2: Alone. (folds arms across chest to indicate he wants to work alone)

R: You want alone, you two want to do it together? What about.. (children spontaneously indicate by holding hands or folding arms if they want to work alone or together)

C3: No.

R: You want alone. You want alone. You together ? (researcher interprets their actions)

C4: Alone.

Focusing on materials, identifying difficulties and *tackling obstacles,* all showed a high level of frequency, and all children in the groups used them at some time during the activity. In the following example, the oldest group designing and making shelters, use all three of these strategies in response to a specific *identification of need,* as they bring their experience to bear in dealing with constraints of availability and modify the materials to suit their needs:

C1: I need one of the green boards for the grass.

C2: Need a green bit.

R: You want a green bit, let me see if I've got a green bit.

C3: Can I have a green bit?

C4: Can I have a green bit too?

R: Well, I don't know if I've got enough green bits.

C2: I need one.

C4: Stuart got one.

R: I know Stuart's got one but that may be the only green bit I've got.

C3: I need a green bit for a canopy.

C2: I need a green bit for ...

C5: Now you can make it green. You can make it green even though it's not green.

C1: How?

R: How?

C5: Colour it, of course.

C4: I know.

C6: Sticky paper.

C5: You can put um, you can get a crayon and draw on it.

C2: I know.

C1: Hold it really tight. (child colours base while other child holds)

C5: Yeah, like that.

Evaluation strategies seemed to be used throughout the activity to support actual work. These seven year olds were interested in evaluating the previous group's models and able to explore 'what counts' as an effective shelter.

C1: That's good. (evaluating another child's model)

C2: There's a bed in the bigger one.

C3: That's it. That's got a bed inside.

C4: I'm going to make a canopy.

R: And there's the canopy.

C4: She's made it green.

C5: So it was camouflage.

R: Yes, camouflage. Why would camouflage be good?

C5: 'Cos if some um bad people come in, um, then they'll just not notice you in camouflage.

C4: Yes, 'cos you'd be safe, wouldn't you?

C3: There's a bed in there and there's a water pump. A water pump. Um, and...

C6: Seats.

R: Mm?

C4: Tables.

Evaluation by peers during the task was often more critical and more likely to prompt modifications:

C1: Tents don't have doors.

C2: We haven't finished this door yet.

C3: It's going to be like this. (draws door on side)

C1: How do they get out?

C3: They come out, they open this flap and crawl out. (cutting flap)

There was a slight variation in the instances of all of these strategies across the three Year 2 groups, generally increasing towards the oldest group, except for the strategies of *personalisation and talking self through*.

4.4 Summary

The findings show that all nine groups of children from Reception, Year 1 and Year 2, used very similar types of strategies even though they were of a different age, from different schools, and engaged in different tasks. Comparisons between years are not appropriate here as the tasks engaged in by the year groups were so different, but finding universal use of the same strategies throughout Key Stage1enabled the taxonomy to be established.

So far, there appeared to be evidence of a set of strategies that was common to three classes of children of different ages, engaged in three different tasks, across schools. It seemed, therefore, that a taxonomy of these strategies could begin to be compiled which would embrace the location of these strategies within the session, and how extensively they were used by the groups, as well as an initial description of each strategy. In analysing the data in order to complete the charts, the complexity of the children's strategies emerged. It was noticed how collective and collaborative they were, and how they linked and built upon each other, or had a different focus at different times. The strategy descriptions within the taxonomy were written and rewritten to include the emerging attributes of each strategy, and enlarged to encompass the diversity of purpose and utilisation.

By charting the common features of the strategies of these first nine groups it seemed that although the strategies used by the groups were very similar, the first indications appeared of possible differences in strategy use and location by different age children within the class. This provided a focus for further inquiry later in the study. Moreover, what seemed to emerge was that different resources were not provoking different *types* of strategies, as there was a general taxonomy across tasks and resources, but different *uses* of strategies. An attempt to demonstrate this is made in the next chapter.

Chapter 5
Developing the Taxonomy for Different Resources

Introduction

The original or embryonic taxonomy, whilst being used to classify the children's strategies, was also under constant revision and change. As the researcher asked questions about children's strategies in relation to the tasks or tools and materials she learnt more, which led to a refinement of the taxonomy so that a more subtle and detailed one was gradually produced. There were, therefore, two levels of reflection: how the groups used the strategies in various situations, and how that helped, on a meta-level, to refine the taxonomy. This focused first on the children and their learning in design and technology, and then on how this affected the taxonomy and made it more detailed yet generalisable, embracing all the aspects of children's strategies for all ages and contexts in the sample.

5.1 Focus on Resources and Tasks

The creation of the original or first version of the taxonomy had prompted questions concerning the role of resources in the children's use of strategies. We have seen from the previous chapter that we do not seem to need a different taxonomy to describe the use of different tasks or resources, but can this really be the case? It is a natural question to ask whether or not types of tasks or resources have an impact. The researcher wanted to know if the prominence of certain types of tasks or tools and materials had any influence at all on their strategic action. Was it necessary to modify the taxonomy at all depending on task or resources? The questions asked were:

* Are the group's strategies influenced in any way by the type of task undertaken ?

* Are the group's strategies influenced in any way by the type of resources used in the tasks?

The tasks selected for comparison covered the three categories of resource used in the study: Hard and resistant materials and cutting and joining tools, soft malleable materials and shaping and smoothing tools, and flexible collage materials and associated tools. The following shows selected tasks categorised according to resources used. (Table 12)

Table 12 Selected Tasks Categorised According to Resources

Resources	Task	Group	School
Flexible materials/ tools	Portraits	Year R	Waterfields Infant
	Cards	Year 2	Waterfields Infant
Malleable, materials/tools	Clay Gifts	Year 1	Gorden Park
	Clay Gifts	Year 1	Waterfields Infant
Hard materials/ tools	Toys	Year 1	Waterfields Infant
	Vehicles	Year 2	Gorden Park

5.2 The First Resource Related Comparisons

The first resource related results can be seen most clearly in the presentation of three specific tasks using the same children in the same school. These groups did the the three categories of tasks as follows: a task using soft, malleable materials half way through Year 1, a task using hard materials and associated tools six months later at the end of Year 1, and a task using flexible materials at the end of Year 2. This oldest group of children at Waterfields Infants designed and made first Clay gifts, then Toys in Year 1, and finally Thank you Cards in Year 2 (Table 4, Chap 3). In order to look closely for any possible influences the resources may have on the strategies a sample of two strategies are taken in turn: *identifying wants and needs*, and *tackling obstacles* (Tables 13a, 13b).

Table 13a The Influence of Resources on the Strategy of Identifying Wants and Needs for the Oldest Group at Waterfields Infant School

Malleable Resources Clay Gifts	**Hard Resources Victorian Toys**	**Flexible Resources Thank You Cards**
C1: We need water? C2: Yes, just a tiny bit. C3: I just need a tiny bit too. R: Why? C3: Or it will go all soggy. C1: Yes it might break. C2: Then we can smooth and roll it again.	C1: I could use this net and bend it. C2: Tim, Look you could use this for a plank for your pirate ship. C3: I need some pins not glue. C4: This wood is too thick to cut through so I need to think of something else. C3: Wait it will be easier to cut with this saw.	C1: Soft toys are the kind of thing you see on a Thank you card. C2: You can have a teddy bear on it. C3: This fur would do for a teddy. C4: If it were Christmas you could send a card with a tree on saying thank you for a present. I like this springy green card.

5.2.1 The Influence of Resources on the Use of One Strategy

When looking at the strategy of *identifying wants and needs* used by the same children at Waterfields Infant School, as they worked with three different resources, it could be seen that there did appear to be a difference, not in the strategy itself but in the way it was used. Looking closely, the focus of the strategy seemed to be different for tasks using different resources. Half way through Year 1, the children used the strategy when working with the clay, recognising the need for water in order to make the clay more malleable. They saw their needs in relation to the procedures they were engaged in, or the *process* of the task. At the end of Year 1, the same group designed and made Victorian Toys as part of a history project. Again the focus of most of the strategies identifying wants and needs, was on the *process* of the task, the materials the group might want to use, and the skills they would need to use them. It was on the doing of the task rather than the end product. Conversely, when this same group designed and made Thank you cards at the end of Year 2, the focus of the strategy was much more on the outcome or the final *product* and needs concerning materials were discussed in relation to this. However, it was necessary to examine another strategy to gain further evidence (Table 13b).

Table 13b The Influence of Resources on the Strategy of Tackling Obstacles for the Oldest Group at Waterfields Infant School

Malleable Resources Clay Gifts	**Hard Resources Victorian Toys**	**Flexible Resources Thank You Cards**
C1: I think the clays too soft to pick up the pot. C2: Yes, it will break if you try to pick it up. C1: Break...mmmmm. I'll just put clay round the edge so its easier to hold.Look.	C1: Can't see this sequin for glue! C2: I think its best to dab it on the wood and then stick it. C1: Yes, I'll dab it on the wood and put the sequin on top. C2: Wipe it with a paper towel to get extra glue off.	C1: How could we make a Thank you card for our teacher? C2: I've got an idea, we could put her favourite flowers in. C3: Yes,but how can we? C2: Open it here and here and they pop out. I made two pop up cards already so I know how to do them.

5.2.2 The Influence of Resources on the Use of a Second Strategy.

Looking closely at a second strategy, that of *tackling obstacles,* engaged in by the same children at Waterfields Infant School, again using three different resources, it could be seen that there did indeed appear to be a difference, not in the strategy itself but in the way it was used. When designing and making Clay Gifts the group were preoccupied with the material itself. All difficulties surrounded its manipulation, rather than the object to be made, in fact the children discarded finished objects again and again, not because they were dissatisfied with them but in order to create the opportunity to work with the clay again. Obstacles were often tackled though the use of more materials such as water or extra clay.

The process of working with hard materials was similarly engrossing and cutting and joining were often problematic throughout the task of making Victorian Toys. The group had problems knowing where to place the glue and how much to apply, especially with particularly small resources such as sequins. When sticking a sequin to a larger surface children often attempted to put the glue on the sequin using a thick spreader. In this way the skills and procedures used by the group focused their attention and demanded a high proportion of their problem solving strategies throughout the lesson.

Conversely, a year later when working with flexible resources to design and make Thank you cards, the same group of children concentrated much more on the cards themselves, rather than how they would make them. They discussed at length for whom they would make the cards and how the preferences of the recipient, for instance their teacher's favourite flowers, could be used in the design. They had some idea of fitness for purpose and began to talk about simple design criteria. In short, they focused much more on the product than the process of the task. However, was this just a sign of their maturity and growing experience?

To summarise, it seems that although the groups used the same strategies regardless of tasks, they used them in a certain way depending on the resources. A number of questions arise as a result of this initial resource related evidence:

* Did the resources influence all the strategies and if so was it in a similar way?

*Could this influence be a function of age because the group tended to focus more on the end product rather than the process as they grew older?

* Did the influence relate to the growing complexity of the strategies as the children grew older?

To begin to answer these questions, it is now necessary look at the way strategies are used in similar tasks in the second school. But first, a closer look at what seems to have happened at Waterfields School.

5.2.3 Focus on Product or Process?

The evidence from the small sample of two strategies would appear to show that although the strategies were the same across tasks there was a different focus for different types of resources. It was suspected that it was the orientation of the strategy or the way it was used that was different, rather than the strategy itself. It was thought that although children used the same type of general strategies across tasks and materials, the availability of certain tools and materials tended to influence the focus of the group's strategies towards either the product or the process of the activity. In describing children as focusing on the *process of designing or making* it is meant that they concentrate on the *manner* in which they are working in order to create the product. They focus on the *procedure or approach* itself, and the *skills and techniques* they use to solve problems.

When we talk of children focusing on the *product in designing and making* we mean that they concentrate on the *final outcome* itself. This is the result of the process and the output of the work. This may entail looking forward and imagining what the product might look like or do,or focusing on the product criteria in terms of its use for users.

It is a subtle argument that while the resources are not influencing the kind of strategies used, they are nevertheless influencing the focus of the strategies, or how the strategies are used. In order to test this product/process hypothesis it was necessary to take a closer look at other data, this time across schools and using other tasks. Therefore, a second resource related comparison was made using both Waterfields and Gorden Park.

5.3 The Second Resource Related Comparison

The second comparison builds on the first, looking at similar tasks at Gorden Park, and then revisiting the Waterfields tasks in greater depth to draw comparisons. (Methods Tables 5a,b,c). To illustrate the product or process focus of group strategic action, and show a single D&T session on one page, the oldest group in each class at Gorden Park was used for these comparisons. These are supported by explanatory narrative. Detailed results of three pairs of tasks, each representing one resource category are shown (Tables 14a,b,c).

5.3.1 Process Focus: Hard Materials

The first category of resource, illustrating a process focus to children's strategies, is that of hard materials and associated tools. The following chart represents the oldest group of Y2 children in Gorden Park School making Moving Vehicles (Table 14a)

Table 14a Product or Process Focus: Hard Materials, Moving Vehicles, Oldest Y2, Gorden Park

Strategy	Process Focus	Product Focus
Personalisation	C1: I'm going to use all the junk boxes I bought from home	C1: I think number 241 for my bus 'cause it goes past my house to my nan's.
Focus on task	C1: I'll make the passenger with lollipop sticks and a card head.	C1: I'm going to make car. C2: I'm making a truck.. C3: A lorry with some bumpers
Identification wants/needs	C1: You need cardboard and lots of things. C2: I need straws or tubes to put the wheels on. C3: I want to use these wheels for my racing car. I need two big and two small. Are there any more?	None
Negotiation	C1: Are we allowed to paint it?	None
Focus on materials	C1: You could use an elastic band. C2: I've got to find a box and some wheels. C1: How about this wheel what's already made. Its cardboard. C3: And there are some wooden ones.	
Practice/planning	C4: These are my instructions . I drew these instructions to myself. I told myself what to do in the writing. That's the box to use, and that's the exhaust pipe down there and they've got to be stuck together, see, arrow going down.	C1: My car will move and have a light C2: Mine will have a scraper on the back. (only examples)
Identifying difficulties	C1: Somehow I've got to get this long stick right through the box and out the other side.	None
Tackling obstacles	C1: I've put all my materials in my box so I don't lose the bits and pieces I've collected.	None
Sharing and cooperating	C1: I don't know how to put these on. C2: Twist them round and round. You do one and I'll do the other.	C1: Hey look at that (tests his vehicle). C2: Oh, brilliant. C3: It goes really fast. C2: Very good. Small wheels go faster than big
Evaluating	C1: You need to use more paint. C2: You could use different wood. C1: Painting it makes it go faster.	C3: It turns the corner.

Chart: Moving Vehicles, Gorden Park Primary, Year 2

The first table in this section deals with the task of Moving Vehicles at Gorden Park School. During this task the oldest group of Year 2 pupils were perceived to be concerned more with the process of designing and making than with the end product. From the beginning of the session their dialogue revolved very much around the materials and tools they intended to use, and reference to what they wished to make was made often only in passing. There was a particularly strong emphasis on planning and modifying, as these older children decided to write and draw 'instructions' for themselves on paper, and any difficulties in making tended to be spoken of in terms of the use or manipulation of resources, rather than with the product itself. However, evaluation and testing still proved more product focused in discussion.

Narrative: Toys, Waterfields Infant School, Year 1

Now for a more detailed look at a task in Waterfields Infant School when children used hard materials to make toys. Was the focus really on process? Before the researcher could begin to introduce the task the group began spontaneously to *focus down on the materials and tools* provided, even when the researcher attempted to direct the focus to the product to be made. They *personalised* the tools and asked questions about their names. These tools and materials were obviously unfamiliar to the group within the school context although they had experience of them at home.

C1: Saws!

R: Saws, yes.

C2: My daddy's got an enormous one!

C3: My dad's got one.

C4: My daddy's got one too.

R: And what else have we got?

C3: Wood.

C1: Wood blocks.

R : Yes, they're called bench hooks.

C5: And what is this ... what is this that is holding it down?

R: A clamp. I understand that you've been talking about, Victorians about Victorian toys.

C2: Yes.

C4: What's that called? (drill)

This did not seem to be a result of not understanding the task indeed quite the contrary. On the second attempt to focus the group on the task in hand the group demonstrated their knowledge and understanding of the task by listing possible things they could make with the tools and materials such as doll houses and slates:

R: Mmm ... teddies, yes.

C1: Marbles.

C2: Wooden rabbit.

C3: Skipping rope.

C4: Hoops.

C3: I think they would have had a hoop and a stick and it goes round the hoop.

R: A hoop and a stick and goes round ... well done. Well done, my goodness, you've got good ideas here.

But although the children obviously had some knowledge of Victorian toys when *focusing on the task* during the introduction they found it hard to decide what to make:

C1: I'm gonna make a ...

C2: I think I'm going to make a ???

C1: You could make something else.

C3: Can I make an aeroplane?

C4: They didn't have toy aeroplanes in Victorian times.

C5: I'm going to make ... I'm not sure really.

Later in the session one child was still unsure what to make:

C 1: I don't play with soldiers.

R: You don't play with soldiers. Could you make some soldiers, though?

C1: I have got Lego too and I make a castle with it.

R: Ahh .. well you can make a castle maybe. Is that a good idea?

C1: Yeah, they might have had toy soldiers and castles.

R: Yes.

C2: They could have had peg dolls' couldn't they?

R : Yes.

C3: He could ... he could make soldiers and a castle.

R: Do you want to try that then?

C1: Yes.

Later the same child used *personalisation* to help relate to this task, drawing on his past experiences of castles.

C1: I've been inside a castle. I've been inside Windsor Castle.

C2: I'm going to Corfe Castle next month.

R: Right, well you know some of the things it has ... it has tall walls. .. and what does it have on the sides of the building?

C2: Big windows.

C1: I could cut some windows out ...

R: Yes, you could, that's a good idea.

The group as a whole were more interested in using the tools and materials than in the end product. The Strategies of *identifying needs and identifying difficulties* were long and revolved around the process of managing and manipulating the tools and materials. The emphasis of the strategic talk was also on the order of procedure,

C1: I'm going to use this.

C2: I'm going to make it with this card

C3: Wait .. it will be easier to cut. (offers hacksaw)

C2: Do you know when using wood ... it's nothing like paper...

C3: Is that better?

C4: This one is really hard to use. (hacksaw)

C3: Well we could get a better one. (sharper)

C5: Can I use the glue gun for these?

C1: Some lolly sticks for the arms? What do you think?

C2: Yes.

R: Do you think so?

C1: Can some of that go on there? (wool for hair)

C2: This could be just what I need. (length of wood)

C6: Hey, these need breaking. Can I use this? (hacksaw)

C5: I've got a lolly stick.

C1: These aren't sticking very well.

R: What, the arms?

C1: It's really hard.

C 2: First I need to mark it. (with a pencil) Then I need to saw it and then stick it hard.

C3: I've got a workshop at home.

Despite finding it hard, the children persevered and supported each other by *sharing and cooperating,* and giving advice concerning choice of materials and procedure:

C1: Well, there's two drawbridges actually.

C2: Is this going to be some of your castle ? (offering string)

C1: Yeah.

C2: Can you open the draw lifts?

C3: Jay, if you're going to take some of the glue I need it for a long long time.

C4: So do I. And I'll need it for a very very very very very short time.

C5: Is anybody using this? (wood)

C1: Yes, that is mine.

C4: I'll show you what you could use. Saw this. (offering wood) Nobody's using it. Saw it, and then it will be in the shape of a door for your castle.

Tackling obstacles also revolved around problems about choice of materials, and order of procedure. The girls working together to make a dolls house and doll realised that they might have considered scale or size before making, but Oliver thought ahead to cut all the wood he needed before gluing.

R: Ahh. And how are you getting on, Jane?

C1: I think I've got it ...(showing use of curtain rings for doll's ear ring)

R: Ahh, you've found that curtain ring ..Yes, that would make a wonderful earring. And the other one! .. for the other side .. excellent.

R: What's gone wrong?

C2: The doll isn't that wide .. and the arms are too long?

R: And has Jane's doll got to get into your house? Yes, ahh ..

C1: And it isn't wide enough.

R: And the arms are too big, .. what could she do then? Ahh, she's taken off the arms.

C3: Need to take off the leg as well.

R: Oh dear, and what will you do?

C1: I'll trim them.

R: You'll trim them oh, and what about the arms..

C1: I need to cut it there .. the arms.

R: How are you getting on Oliver?

C4: I've got all the bits I need but I'm not gluing yet.

R: Ahh you're not gluing yet, no. You're getting all the bits you need first, I see..

In the short discussions concerning the product two girls working together confused the task altogether, and forgot for a time that they were making a Victorian doll's house.

C1: Are you making a Barbie house?

C2: Yes, and this is Barbie.

C1: This is a doll's house .. it's made out of nothing except wood and glue.

C2: This goes ... that's going to go in the Barbie house.

C3: Doll house, not a Barbie house ... it's a Victorian dolls...(another child reminds them of the task)

Interestingly, the children spontaneously focused their self *evaluation* on the process and not the product. In this first example a child was eager to use the researcher's audiotape to record a mock radio broadcast about the boat he had designed and made:

R: Tell me about yours.
C1: Can I talk into the recorder?
R : Yes, fine.
C1: Now, how to make this boat. All you need to do is get a piece of wood ... pieces of wood .. saw and glue .. felt tips as well. Now, to make the boat .. you need to get a piece of wood and saw it till it's the right length for your boat. Then .. you have to cut a little triangle and stick it on the front .. a little smaller if you like, it doesn't matter .. well ... the back of the boat .. you need to just get a piece of wood and then stick another piece of wood on top. You need to get a big piece of wood .. this piece of wood and this piece of wood and you need to saw a funnel, OK? Then .. and you need to glue it all together. Then, after that .. you let it dry overnight, then pull your felt tips out and colour it. I've already coloured the back of mine .. some of the back of mine .. and the funnel. So, until the next time I'm back, ta-ra!

This second example also shows how the design and make process seemed to be all important for the group, rather than the product.

R: Tell me about your doll house girls.
C1: Well, we .. when we made the bed we stuck two bits of wood together to make a big mattress, and put a pillow on, and then put a cover over it .. and for the table we just got a bit of wood, then we sort of decided that bit .. and then we just got some glue and stuck it like that. And then, when we made the chair.
C2: ... when we made the chair and where we ... I found that .. glued that bit together and that bit together .. and then instead of a chair instead of a table .. and it .. stuck those on.
C1: And when we made the cooker .. we .. well I stuck wood together to make a box .. but I left two spaces at the bottom and that bit .. and then I stuck them all together .. and I drew on there.. to make the cooker .. sort of the stuff on the cooker .. then I stuck it on there.

5.3.2 Product Focus: Flexible Materials

In contrast to children's process focused reaction to certain resources in certain contexts, it appeared that other resources may prompt a product focus at certain times. Comparisons again build on previous evidence of Thank you cards from Waterfields School. This was matched with Gorden Park children who made Self Portraits also with flexible, collage materials (Table 14b).

Table 14b Product or Process Focus: Flexible Materials, Self Portraits, Oldest YR, Waterfields Infant School

Strategy	Process Focus	Product Focus
Personalisation	None	C1: I've got scruffy hair when I wake up in the morning
Focus on task	None	C1: Bow ties.....you could put a bow tie on.
Identification wants/ needs	C1: I want white.....you need white. C2: Have you got a red there? C3: Orange, orange!	C1: You could do you in your school uniform if you like. C2: I've put a really big head. C3: Oh, I need the ears.
Negotiation	None	C1: Can you do just down to your top button?
Focus on materials	C1: What is all this material for?	C1:Shall we use the mirrors to look at us? C2: Look , I've made that hat. C3: I've made a foot.
Practice/planning	None	C1: I'll do the picture of myself on that side and put my name on this ...cos this side doesn't matter.
Identifying difficulties	C1: There's nothing really suitable for my jumper.... C2: I can't get the right shapes for my body.	C1:Your going to have tiny legs, Mark. C2: What does the yellow writing on my school jumper say?
Tackling obstacles	You need that yellow stuff....yeah....yellow stuff.	C1: I need a headband. C2: I have to copy the writing on my jumper.
Talking self through	C1: I'm going to stick that one on.....yes, I have.	C1: Now I've got a big fat tummy.
Sharing and cooperating	C1: I found that (material) C2: No I found that. C1: He's not sharing. C2: I am sharing.	C1: He's juggling with fire. C2: Look you could do this. C1: I hope the fire doesn't hit the ceiling.
Evaluating	C1: The pink shows up well. (few examples)	C1: Let's see your picture, Mark. C2: That doesn't look horrible, does it? C3: It doesn't look horrible at all. C4: It does look quite nice, doesn't it?

Chart: Self Portraits, Waterfields Infants, Oldest Year R Group

It can be seen from the chart that the reception group were mainly focussed on the task of self portraits. This egocentric activity was observed to be extremely absorbing for the group. The mirrors available for the children's use probably added to the self interest, so that the children were involved in the demanding task of representing their own reflection on paper. These self portraits were made for the end of year parents' evening display, so were described as 'important' by the class teacher and each child was aware of the need to do a 'good job'. In contrast to reception children's usual preoccupation with the properties of the materials, especially colour, there was little interest in this, in fact one child asked, 'What is all this material for?'. The group were much more concerned with their own appearance as reflected in the portrait, and making it as true to life as possible. One boy wanted to reproduce faithfully the writing on his school jumper and the girls were keen to include the the detail of hair bands and slides. Tools and materials seemed to prove interesting only in so far as they facilitated this. One reason for this may have been that the resources available were unremarkable, and had been used by the group many times before.They were challenging only in that they were more limited in range than was needed, as the children wanted an exact match of their own clothes in shape and colour and were frustrated when they could not find it. This restricted how far they could extend beyond full-face portraits. However, one child reposed the task itself to portray himself as he would like to be. The task had so captured his imagination that he depicted himself as a fire-eater in the circus.

Narrative: Thank you cards, Waterfields Infants, Year 2

The second example of children working with collage materials and associated tools is that of groups of Year 2 children at Waterfields Infants making Thank you cards for classroom helpers at the end of the school year. The children of all three groups doing this task immediately engaged in discussion about the real need to give Thank you cards to people who help them:

C1: Mrs Helcame helps us with Maths.

C2: Mrs Shepherd hears us read and I see her today.

C3: Mrs Winters, she helps us sew.

C4: I want to make our teacher a Thank you card.

The group reflected on what they knew about the cards from their experience exposing gender issues:

C1: If they're for girls they might have a big flower on.

C2 : On my thank you card at home you've got a little rat. There's three stages. The first one he's got a piece of paper, the second one he's muddling with all these paints and scissors and crayons, and the third one he's got himself sorted out.

C3: Well, that's like a story on the front isn't it?

C4: Well, you usually see 'Thank you very much' written and a picture on the front with someone with a present or something underneath.

C3: Soft toys are the kind of thing you see.

These children were beginning to build quite a good concept of a Thank you card and found the task very engaging and discussed it at length. When focusing on resources and the organisational process of designing and making they were, however, brief and business-like, demonstrating their experience in this area as the oldest Key Stage 1 children.

C1: We've got all sorts of material in this bag.

C2: Here are the scissors.

C3: This is magic glue. It goes on purple and dries white.

C4: This fur would do for a teddy bear on my card.

C2: We need card first.

C5: There's lots of colours to choose from.

The children also demonstrated their skill and experience when discussing the process of folding the card:

C1: Now you fold it.

C2: Yes but this way, corner to corner.

C3: Like a book.

C2: You get the corner and put it to the other one.

C4: You should stand it this way (on long edge).

C3: Or that way.

C5: The corners always try to get apart, don't they?

C3: You have to press hard.

C5: They spring apart.

C6: You need to put the straight lines together.

But even in the middle of making the cards, their focus was still on retaining the end product to take home. They advised each other:

C1: Don't forget to put your names on.

C2: Put the picture on one side and your name on the other, then it won't show.

Showing and evaluating occurred when the Year 2 groups had gone some way to creating a product and were aided by a mix of talking themselves through the task and group conversation. There was now a noticeable focus on the task itself shown by a concern for quality in terms of authenticity. These children wanted their cards to look 'real' and adopted devices that they had seen used in commercial cards. For instance,

C1: Look at my card already - when people look at it, it looks real like in a shop.

C2: Look at my whale in the sea.

C3: I'm doing little windows on my aeroplane card and drawing the pilot here.

C4: I'm going to use all these materials. Where's the pencil?

C5: Once I had a birthday card that was like this. It said 'Happy birthday' through the gap. (showing window in own card)

C2: So you don't waste time writing thank you twice.

C4: Yes but it does take time cutting out the hole.

C3: I'm going to write 'thank you' in the windows of the aeroplane all along the side.

C5: I've got balloons coming out for the people's mouths like you see in cartoons. Mrs Harkens saying 'You did well' and I'm saying 'Thank you.'

5.3.3 Process Focus: Malleable Materials

Finally, more supporting evidence from Waterfields children working with clay, Y1 children work with clay at Gorden Park. In contrast to children's product focused reaction to flexible collage materials, it appeared that the third category of resource, that of clay, is powerful in prompting a process focus. For instance, when children at Gorden Park School made Clay Gifts using modelling and shaping tools, like those at Waterfields School, their strategies seemed to be concentrated almost exclusively on manipulating and exploring the properties of the resources (Table 14c).

Table14c Product or Process Focus: Clay Gifts, Y1, Gorden Park.

Strategy	Process Focus	Product Focus
Personalisation	C!: My dad has tools. C2: Everyone's dad has tools. C3: Where do you buy clay ?	None
Focus on task Identification wants/ needs	C1: We can use an apron. C2: I want a blue one. C3: I need the red. C4: I want the big bit of clay. C5: I need that small bit.	C1: Are we making models? None
Negotiation	C1: Umm, it's squashy. C2: A bit sticky.	C1: Are we going to take the models home? C2: You're not allowed to make guns are you?
Focus on materials	C3: Um, it's a bit wet. C4: It's a bit shiny. C3: Water in it.	
Practice/planning	C1: Are we going to paint these afterwards? C2: Are we going to wait until they dry?	None
Identifying difficulties	C1: If you don't have a plastic bag it will dry up. C2: It would sink away. C3: Go all hard.	None
Tackling obstacles	C1: This is getting hard. C2: I won't be able to make anything. C1: I think we gotta put paper on it. C3: Well it will get dried up in the plastic. C4: Put it in the bag for a long time.	None
Sharing and cooperating	C1: You hold it there. (pot) C2: You can't hold the handle. C1: Handles come off. Never mind. Put it back quick.	C1: Why don't you make a rabbit? C2: I'm going to make a tortoise as well. C3: That's his leg.
Evaluating	C1: Do you want to try making something else with this piece? C2: Yes but it needs to be big and fat otherwise when it dries it will fall apart.	C1: That's not a bear. C2: Yes it is, and that's a tortoise C3: What's this? C2: And they're friends

Chart: Clay gifts, Gorden Park, Y1

For the children, clay was perhaps the most powerful material in the study. It was used in both schools for all groups at Year 1. On all occasions it dominated the focus of group strategies throughout the D&T activity and it was highly valued by the group. They saw it as important that each child was given an equal share of this material and models were made in order to use up each small piece rather than for their own sake. The children were fascinated by its consistency and texture, and by the fact that it did not behave like playdough or plasticine, and had to be 'big and fat or it would fall apart'. They were confused by the fact that it dried out, and thought that putting it back in the plastic bag would replace its moisture. No member of this group thought to use water with it, but they spontaneously used the modelling and shaping tools to decorate their models. The task itself, to make Celebration Gifts, was only briefly discussed at the start of the activity and quite forgotten later. It seemed to serve only as an excuse to manipulate the material, and models were destroyed by the children regardless of quality and the clay re-used a number of times. In this way the children moved from making Christmas presents and candlesticks for Hanukkah, to dinosaurs and monsters, then guns and motorbikes, and finally bears, elephants and tortoises, as they explored the properties of the clay.

5.4 The Product and Process Focus of Different Tasks

When analysing the different tasks in the study, regarding the emphasis children put upon the process or product during the activity, it was found that different tasks produced different results. Moreover, certain types of task seemed to produce a similar reaction. For example, Greetings Cards, Invitations and Self Portraits in the reception classes, all collage material based tasks, appeared to generate an emphasis on product focused strategies, while the designing and making of Clay Gifts, Buildings and Toys in Y1, all generated a process focus. The creating of Moving Vehicles and Shelters in Y2 also generated a majority of process focused strategies (Table 15).

At first glance the dominant variable appeared to be the age of the children. The obvious conclusion was that the youngest Key Stage 1 groups concentrated their energy on the product of D&T tasks, moving to process and then back to product at the end of the key stage. But on closer inspection there seemed to be a link with the resources used in the tasks. Perhaps it was the use of hard materials with associated cutting and joining tools, and malleable clay,with shaping and smoothing tools, that focused children towards process, and collage materials, and their associated tools, that concentrated children on product. However, there was also a contextual variable. The groups, in general, were much more familiar with collage, scissors and glue, and less so with clay, wood, saws and glue guns.

A wish to experience the challenge of working with new and interesting materials would be a convincing reason for children to focus their strategies on the process of

designing and making during some activities, but this seems to be only part of the story. There is also evidence in the data that the purpose of the product itself is significant. Tasks which fulfil a real need for the children, such as making Christmas or Thank you cards, appear relevant to them and focus their effort and concentration. The class can take these home, share them with family or give them to others, and they may stand alongside or be valued as much as or even more than commercial cards. Self Portraits fulfil a similar purpose. Whereas, tasks such as the making of model Rain Forest Shelters, Buildings, or Vehicles remain fairly remote to young children, and even the task of Victorian Toys created models rather than durable play things. Clay Gifts may appear to contradict this idea but here the power of the material itself may focus the children so strongly that all other motivation is forgotten.

Table 15 Focus on Pupils' Strategies Related to Task, Age and Resources

Task	Age	Resources	Product	Process
Cards	YR	Collage	*	
Invitation	YR	Collage	*	
Self Portraits	YR	Collage	*	
Gifts	Y1	Clay		*
Buildings	Y1	Hard Materials		*
Toys	Y1	Hard Materials		*
Vehicles	Y2	Hard Materials		*
Shelters	Y2	Hard Materials		*
Cards	Y2	Collage	*	

The results presented indicate that children's strategies may be determined by a combination of the resources used and the authenticity of the task itself. Strategies in design and technology may then be regarded as context specific in this way, as well as being dependent on the personalities, capabilities, and experiences of the group. It appears that in certain D&T activities group strategies are product driven, where the children are focused predominantly on knowledge and understanding of the task or product; and in others they are process driven, where children are mainly concerned with how they manage materials, tools, and practical skills and techniques. When the resources are perceived as new or interesting, children focus their attention on this challenge. When the resources are less interesting, but the task is perceived as real and relevant to children they focus their strategic energy and ideas on what they need to make rather than how to make it. Consequently, in any D&T activity, one of the main concerns for the group will be to prioritise the most interesting challenge in terms of the task or the resources, and to focus their strategies mainly in that direction.

5.5 The Structure of the Taxonomy

5.5.1 Sequence and Time Related Comparisons

The next comparisons focus on the sequence, frequency and duration of children's strategies, posing questions concerning the structure and dimensions of the taxonomy, and relating them to the development of children's strategies at Key Stage 1. The questions asked were:

* Do strategies occur in a certain sequence? Are certain strategies a prerequisite of others?

* Do sequence, frequency and duration of strategies relate to children's ages?

The findings were based on the oldest groups in each year at both schools. These findings present comparisons regarding the order in which the strategies occurred and their frequency during a range of tasks. An attempt was also made to consider other dimensions of the strategies, such as intensity, pattern and overlap within the taxonomy. The duration of the strategies within the D&T sessions was noted. The lessons tended to take longer as the groups got older, the reception children taking about 60 minutes, Year 1 children 75 minutes, and Year 2 groups approximately 90 minutes. The comparisons were made within schools, for consecutive tasks representing two categories of resources, tracing the same children's strategy dimensions as they grew older. (Chapter 3, Tables 6a, 6b) The first comparison looks at the children at Waterfields Infants making Portraits in the reception class, and Thank you cards two years later in Year 2 (Tables 16a and 16b).

Table 16a Dimensions of Strategies: Waterfields: YR, Portraits

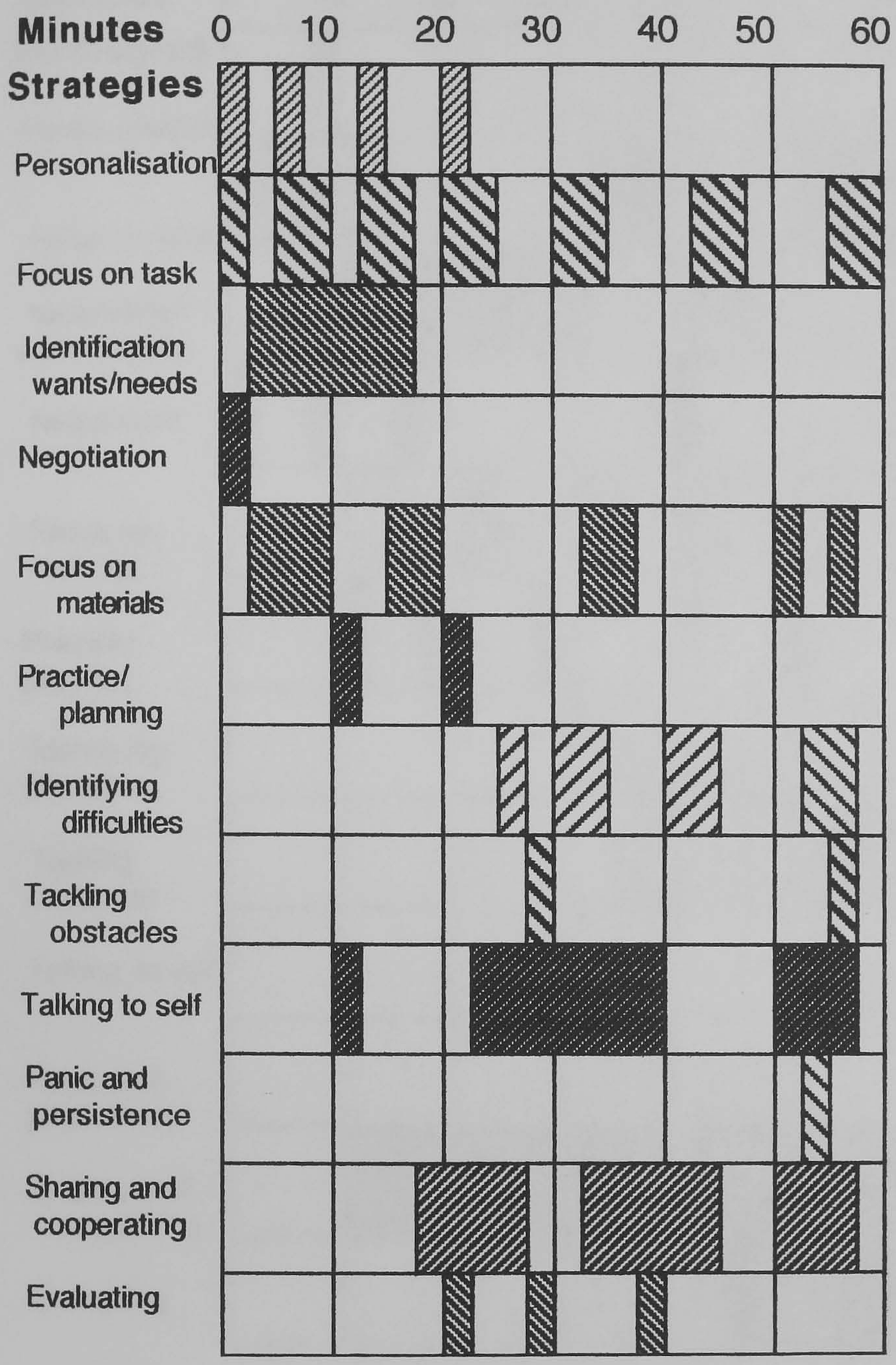
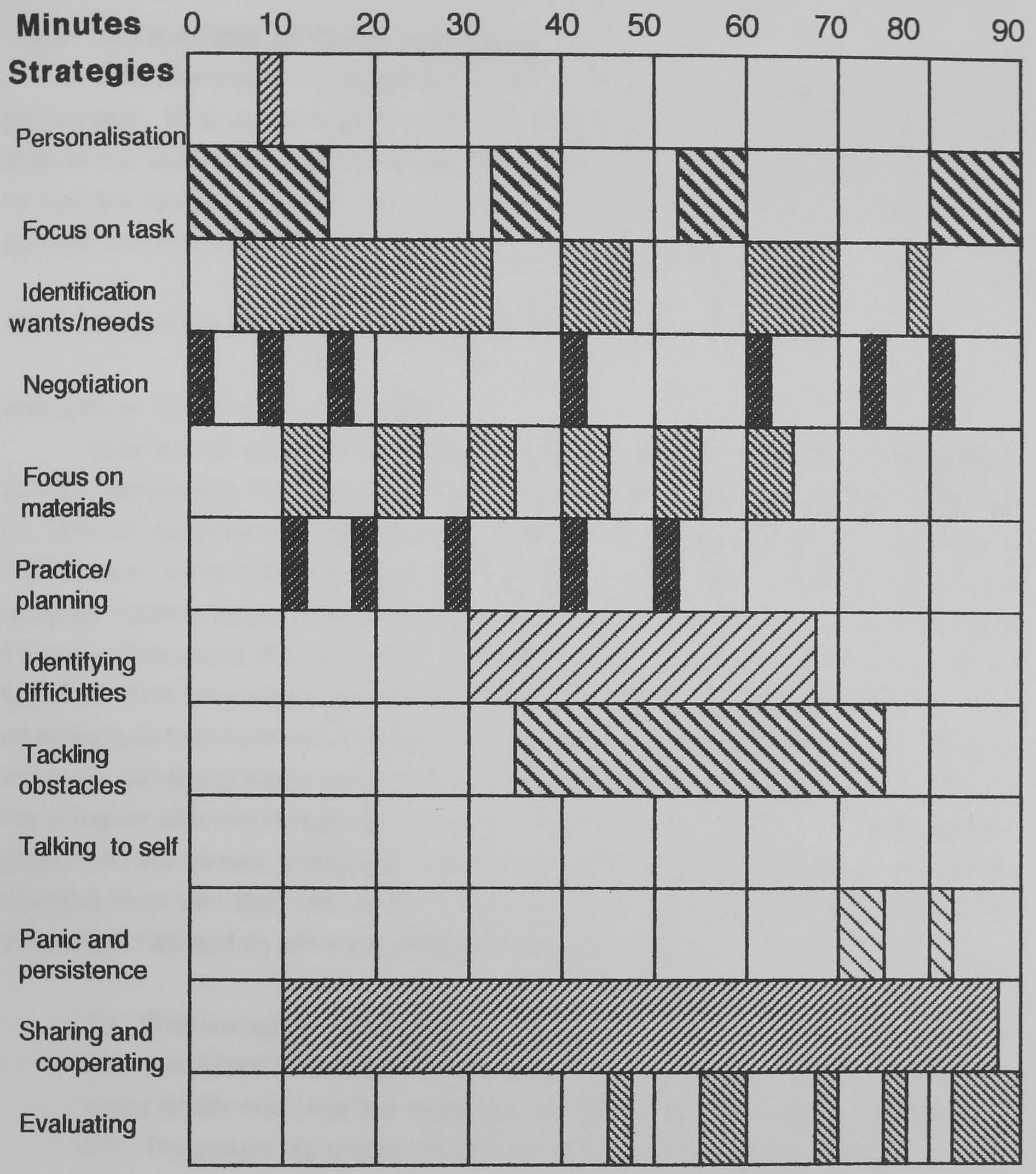


Table 16b Dimensions of Strategies: Waterfields: Y2, Thank you cards



5.6 Dimensions of Group Strategies

The dimensions or properties of group strategies were sequence, frequency, and duration. That is, the order in which the strategies occurred; whether they occurred often or not; and the length of time they took to occur, whether long or short. The tables for both the reception and the Year 2 groups can be described in relation to these three aspects, and then compared.

5.6.1 Comparing Strategy Dimensions in the First School

Reception Children's Strategies

Now we will compare the Dimensions of YR and Y2 Strategies at Waterfields School, starting with the Reception Class strategies. The strategies over the 60 minute D&T session occurred in a certain sequence. Some strategies occurred at the start of a D&T session, some in the middle or at the end, and some recurred throughout. These reception children began by focusing first on the task. They then used *personalisation* frequently throughout the first part of the session to support their understanding of the task. They then, very briefly, *negotiated* what was allowed in terms of the use of mirrors, for example to help them with their self portraits. They *focused in more depth on materials* and tools, *identifying wants and needs* in terms of colour, fabric, and glue, and continued this at regular intervals throughout the session. Planning first took the form of play as they played with the mirrors, examining their own reflections and investigated the materials, matching them with their skin or hair colour or their school uniform. They then began some short, rudimentary *planning* through discussion such as

> C1: Shall we put our name on?
> C2: Yes. I think I'll do the picture of myself ..er....on that side and....I'll put my name on this side...cos that side doesn't matter. (back of portrait will not show)
> C1: I'm going to put a really big head so my mum can see me. (portraits for parents' open evening)

Much of this planning was in the form of talking to self, which continued strongly throughout the main part of the session. *Talking to self* occurred during *identifying difficulties and tackling obstacles*, as children used it to think aloud when problem solving. Identifying difficulties came necessarily before tackling them. At this age children could recognise that they had a problem but not always know what to do about it, so some difficulties were ignored or side-stepped by changing direction. For example,

> C1: I can't find the right shapes for my ears...There's nothing really suitable. I'll have to go without ears.
> C2: Or put more hair on round your face.

Sharing and cooperating was longer in duration than other strategies, and was more likely to happen when reception children were problem solving, and might be accelerated by panic conditions when it was time to finish. *Evaluating* was sparse and took the form of showing work to peers, and making short comments, of either a very kind or very critical nature, throughout the middle of session:

C1: Look, she's got a beard. (commenting on too much glue on chin of portrait)
C2: It's stupid.
C3: Let me see your picture, Mark.
C4: That doesn't look horrible, does it?
C3: It doesn't look horrible at all.
C4: It does look quite nice, doesn't it?

Year 2 Strategies

When comparing the dimensions of the same children's strategies at Year 2, making Thank you cards, it is at once noticeable that although they occurred in roughly the same sequence through the lesson, the duration of the strategies increased, on the whole, and they became more clearly defined. *Focusing on the task* entailed a long discussion of the variety and type of card that could be made, and the children identified a long list of needs based on their previous experience. As one child remarked, 'I made two pop-up cards already so I know how to do them'. Identifying difficulties extended in duration, and tackling obstacles matched this, while the children chose from the start of making to work together and continued this *sharing and cooperating* throughout the task.

Personalisation and *talking to self* decreased in frequency or declined altogether, but other strategies, such as *negotiation*, increased and occurred more regularly. Children were now able to speculate as to how they might negotiate making a combination of types of Greetings cards. One child suggested, 'Well, if it were Christmas you could send a card saying thank you for a Christmas present'.

Focus on materials and *Practice and planning* also happened at regular intervals now, in the main part of the session. There was less self structured play now, exploring the materials in this way, but more experimenting with materials in terms of shape, space and measurement through planning how they might fit on the cards before actually gluing them down. Children were seen to lay fabric across the card and cut it to the right size while in place, and to judge the effect of certain materials put carefully in place before joining. In this way they Practiced before doing. In Year 2 children were also beginning to plan on paper:

R: What are the girls doing?

C1: Planning it out.

C2: We put a piece of white paper over the top of the card and drawn round the outline so as to make sure the plan is the same size as the card.

C1: I've folded my white paper at the bottom so it's the right size.

C3: This net will be good for sea plants.....

C1: I'm not drawing it exactly. It's just my plan so I don't have to draw it absolutely with everything right.

C2: I'm going to do this part then cut some ribbon. I think I'd better glue it with strong glue - white's (strong white glue) better than this stuff from the tube.

C1: I'm going to change it slightly from the plan when I draw it on the card. You don't see the pattern and I want it bigger. Anyway, I'm going to write something down the bottom in the space.

It can be seen from the tables that there is a relationship between identifying difficulties and tackling obstacles. In the reception class the first was not always followed by the second. The reception group making portraits could *identify difficulties* but not foresee problems or easily act to tackle them:

C1: There's nothing really suitable for making my jumper ..

C2: But you've got mine.That's my piece!

C 3: I can't get the right shapes for my body. (searching in the box)

C1: I want to use this colour .....?

C2: Green.

C4: Oh God.. now I've slopped that glue all about.

C5: Where's that other ? thing? (safety snip)

C6 : I dunno.

C2: There's so much green..but not enough red in the bag..

C 4: That one's stuck on.

C1: What does my school jumper say... on the ..front...I have to copy it for my picture.

The relationship between *identifying difficulties* and *tackling obstacles* is more marked at Year 2. The Year 2 group were now able to think ahead when identifying difficulties and could act quickly to tackle them or sometimes avoid them completely:

C1: Rub those two out.

C2: Can I get some more newspaper because the place I'm writing is a bit uncovered.

R: Yes, fine.

(Long period as children work in silence.)

C3: The card opens here and I'm gluing this piece inside it. It advertises this glue in the Beano.

C4: I'm getting very buttery fingers here. (glue).

R: You're very quiet - all working away!

C2: I'm going to do it lightly so it won't ...

(Long period of quiet again.)

R: There's someone carefully using the glitter.

C5: So that other people will have some. Trying to get it all stuck - it's hard.

C4: Look what you're doing - you're spilling it.

C3: Now just get this. (lid)

C4: Use the lid there put so....(scoop it up)

5.6.2 Comparison of Strategy Dimensions in the Second School

The first comparison looked at children in Waterfields Infants working with collage materials in Year 1 and Year 2. D&T sessions in Year 1 took 75 minutes, and Year 2 groups took approximately 90 minutes. The second comparison looks at a group of children at Gorden Park, first making Buildings in Year 1, and then Shelters in Year 2 (Tables 16c and 16d)

Table 16c Dimensions of Strategies Gorden Park: Y1, Buildings

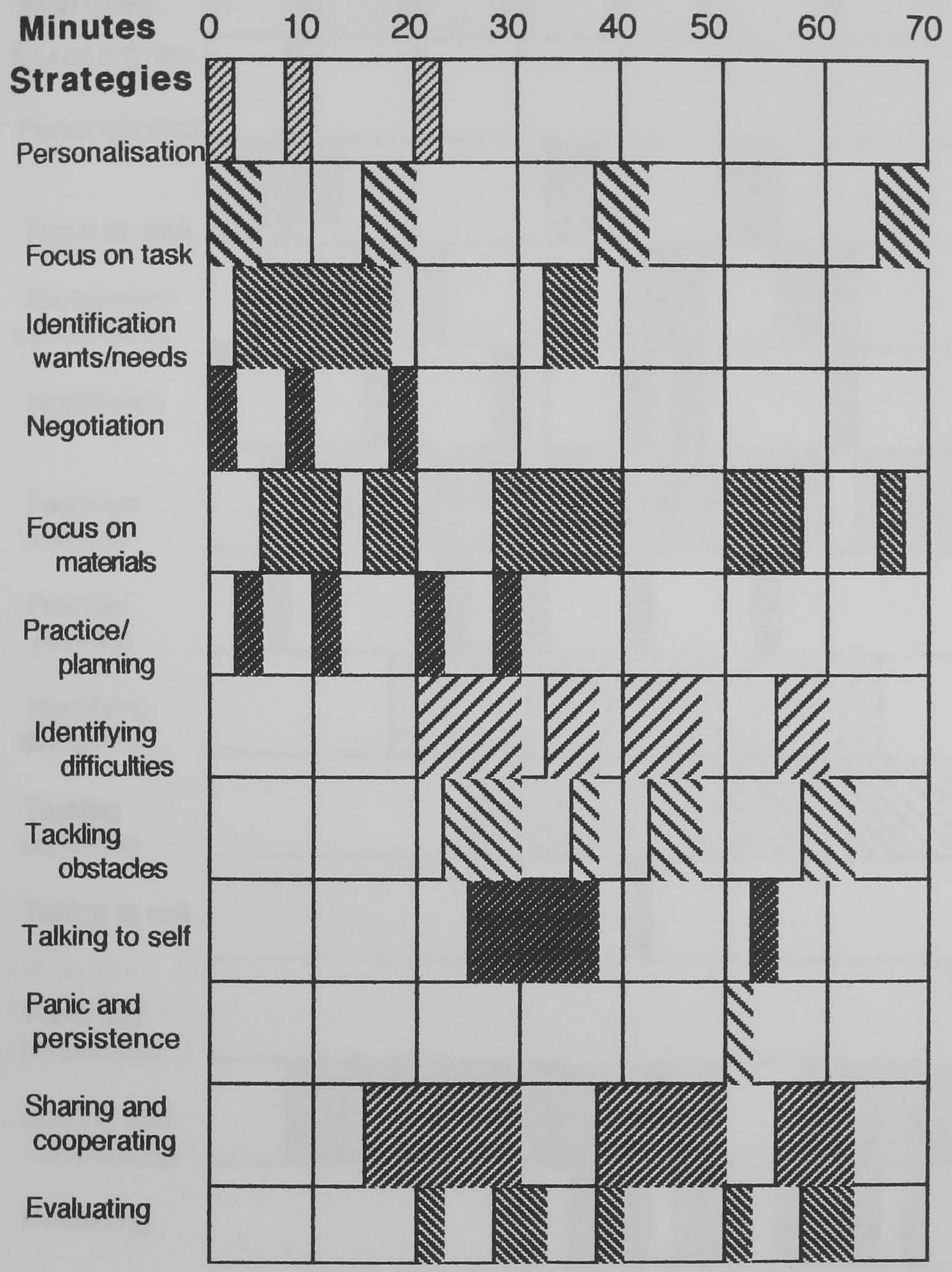
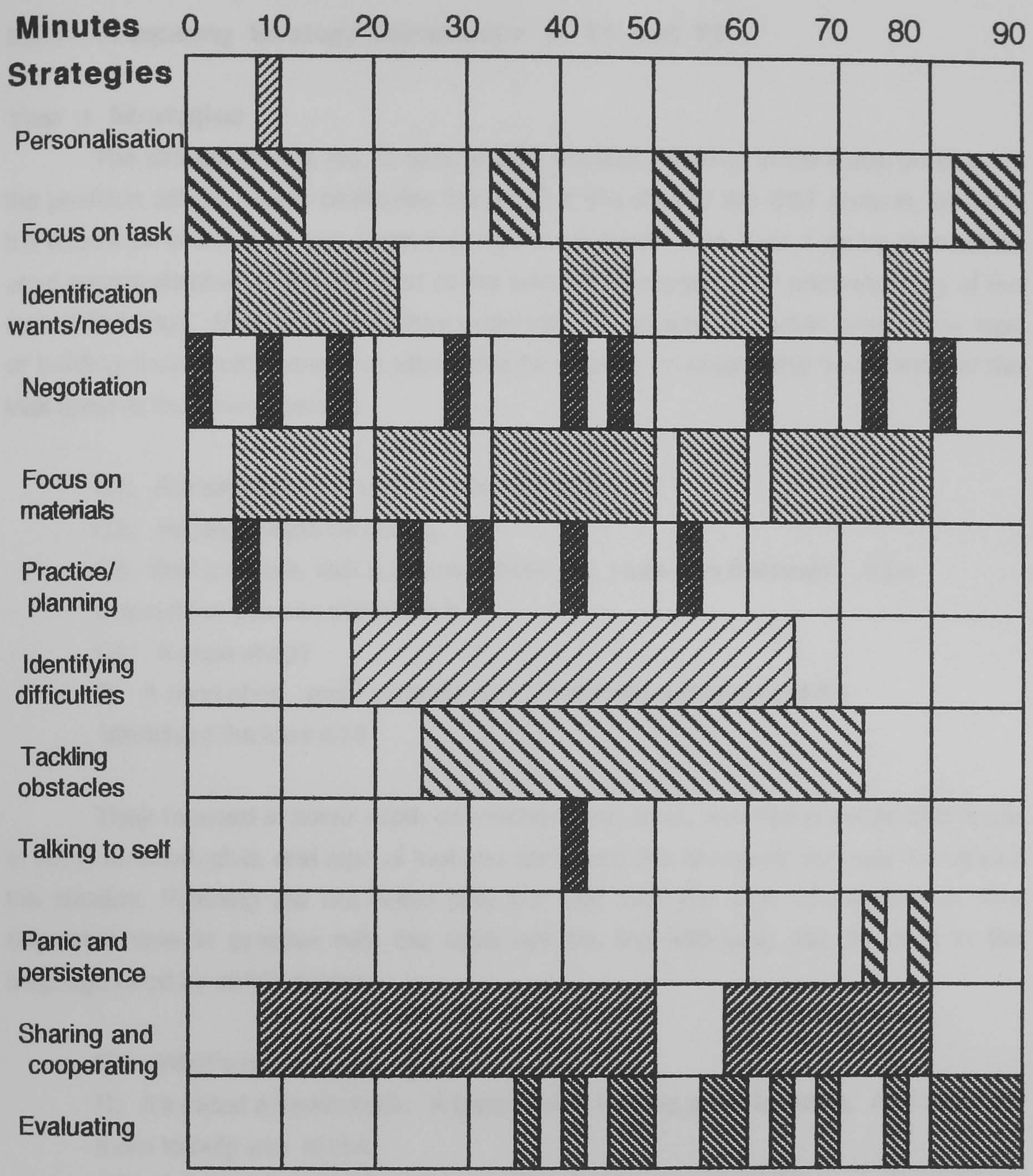


Table 16d Dimensions of Strategies: Gorden Park: Y2, Shelters



5.6.3 Comparing Strategy Dimensions of Y1 and Y2

Year 1 Strategies

The strategies over the 75 minute D&T session occurred in the same order as in the previous school. Some strategies occurred at the start of the D&T session, some in the middle or at the end, and some recurred throughout. The Year 1 group sometimes used *personalisation* in the first part of the session to support their understanding of the task of Buildings. While doing this they *negotiated* what was allowed in terms of the type of building they could make and attempted to re-pose or extend the boundaries of the task towards their own interests:

C1: Are we allowed to make a newsagents?
C2: No, that would be boring.
C3: Wait a minute, wait a minute..a hide-out, I saw it on the news ....it's a dug-out but you can still live in it.
C4: A shoe shop?
R: A shoe shop, and I suppose you could make a dug-out but it's stretching the idea a bit.

They focused *in some depth on materials* and tools, *identifying wants and needs* in terms of wood, glue, and type of tool and continued this at regular intervals throughout the session. Planning did not entail play but first took the form of practice as they requested time to practise with the tools but the link with play can be seen in the language used by children here:

C1: What's one of them, here?
R: It's called a bench hook. A bench hook, and we use it to cut on. And I've put it there to help you to cut.
C2: Is it hard to get off? (pulling at clamp holding bench hook)
C3: Then first of all we have to do a bit of play with it, I mean practise cutting!
R: Yes , alright.
C4: Urr, no. (nervously)
C: Yes! (in unison)
C2: I think I'd better turn this round. (hacpsaw)

Planning was through discussion at Year 1 but the group engaged in physical planning such as putting certain materials aside for use later and thinking ahead about resources. *Identifying difficulties* was now followed closely by tackling them as children began to use their experience to solve problems. They still did this through a good deal of *talking themselves through* their problems and occasional *panic,* but *sharing and cooperating* was increasing to support this and *evaluating* was becoming more thoughtful.

Year 2 Strategies

During the 90 minutes when the same children made Rain Forest Shelters they used much less *personalisation* but much more *negotiation,* although this time the negotiation concerned working with peers and use of materials and procedures. They spent some time deciding who would work with whom and whether they were able to use certain tools and they also negotiated physical help from the researcher. There was a much stronger *focus on materials* in Year 2 and a greater emphasis on *planning* ahead through discussing the use of materials with working partners and putting aside certain resources. Extended discussion about possible procedure was also evident at this stage:

C1: I'm doing it, I'm doing it with Paul.
C2: Right , ...your piece can be the roof and I know, we could um.
C1: Yeah, get those.....(pointing to the tools)
C2: We could make a forest floor here (pointing to some cardboard).
C1: Just a minute, Paul.
C2: Get this off. Off here (an irregular edge). This is for the side. (holding some balsa).
C1: Just a minute.
C2: This is for the side too. (support stick)
C1: Just in case it falls over.

Identifying difficulties and *tackling obstacles* seemed to fuse together, one following the other in continuous problem solving. *Talking to self* had now diminished and there were long periods of quiet working or urgent discussion about procedure. *Sharing and cooperating* was now extensive. *Evaluating* had also increased and had moved somewhat towards the end of the session. Together with the children's appreciation of assessment criteria, it was becoming more of a useful tool for modifying and improving their work.

5.7 Summary

On the whole it seemed that the order in which the children's strategies occurred throughout the sessions tended to remain constant, but that their frequency and duration increased as the children grew older, becoming longer and more clearly defined or more frequent and occurring in a more regular pattern. Within the transcripts generally, the length of the strategies appeared to increase and become more pronounced as the children grew older.

Younger Key Stage 1 children moved from one aspect of the task to another very quickly, so that the units were interwoven, spasmodic and short lived, while older groups spent longer on sub-tasks, with concentrated periods of intense activity or quiet work. *Talking themselves through* sub-tasks occurred more in younger groups and gradually lessened.

The sequence of the strategies varied to some degree. Some strategies occurred at the start of a D&T session, some at the end and some recurred cyclically throughout the lesson. Six months seemed to make little difference to the sequence, but a year or two years saw some change. *Personalisation* and *evaluation* were examples of this, as the former was located very much at the beginning of the activity in younger groups and the latter towards the end of the task with older children.

Negotiation was used very briefly at the beginning of the lesson by reception groups but extensively by older children throughout the activity. The use of other strategies was much more complex. For example, *focusing down on the task* occurred continuously in older and younger groups both in relation to the context of the task and the product to be made. In both younger and older groups the children appeared to have little difficulty in relating to the context of the task in the introduction to the session, for example self portraits or rain forests, but the younger groups went back egocentrically again and again to the task, focusing on it many times during the lesson. The oldest groups took concentrated periods of time to extend their understanding about the type of shelter appropriate for a rain forest.

When *identifying wants and needs* across the age range, older groups were able to make more specific choices of materials and were able to describe the properties of these materials, for instance colour, in greater detail. More complex procedural knowledge was also demonstrated in that there seemed to be an unspoken consensus regarding the order of procedure when making a greetings card, a clay gift or a building, although this needed to be checked against teacher expectations for what was 'allowed' in the classroom.

When*focusing on materials,* the properties of new materials were explored through play in the earlier lessons. Limited group requests to Practice skills in Year 1 moved to the ability to begin to plan ahead in discussion and sometimes on paper in Year 2. There seemed to be a complex interrelationship between play, Practice and planning which needed to be explored through further comparisons and analysis.

Identifying difficulties and*Tackling Obstacles* seemed to sit together, one necessarily being a prerequisite to the other. Children could *identify difficulties* at the reception level but rarely act to tackle them. This accounts for a number of incidents of strategies identifying difficulties not being followed by tackling obstacles (Table 16a), but by Year 1 groups might foresee problems and act quickly to tackle them (Table 16c). By Year 2 they acted in a continuous problem solving way of identifying and tackling difficulties or sometimes foreseeing and avoiding them altogether (Table 16b and d).

Sharing and coopperative strategies were generally extended as the children grew older. Groups first gave general acknowledgement of others work, but were first able to provide physical help during making and then share specific ideas towards modifying or enhancing products. In Year 2 the children requested paired work, could make joint decisions, and demonstrated an awareness of their own cooperative competence.

Incidents of *panic and persistence* occurred towards the end of most activities in the study throughout the age range and were often provoked by reminders that lesson time was running out. *Showing and evaluating,* however, was evident spasmodically at the reception level, when more showing and less evaluation occurred, and gradually moved towards more sustained periods of evaluation but less overt showing or offering work for appraisal as the children became more experienced. Towards the end of Key Stage 1 evaluation strategies were found more likely to occur at the end of the lesson. Again questions arose about the complex interrelationship of showing and evaluating and the types of evaluation strategies that children might use at certain times and ages. This necessitated further in-depth comparisons.

In this way, time related variations in the general taxonomy indicated possible change in the pattern of children's group strategies as they grew older. Some strategies seemed to interrelate with, or to follow others. Moreover, the sequence, frequency and duration of children's strategies seemed to relate to their age. These results prompted further age related comparisons, described in the next chapter.

Chapter 6
Age Dependent Variations in the Taxonomy: The First School

Introduction

The previous chapters have described the development of the taxonomy focusing on the D&T tasks themselves, the resources used during these tasks, and strategies used. Chapters 6 and 7 now explain the final and most important development of the taxonomy, this time focusing on possible strategy change as the children grew older. Here questions were asked concerning how general the taxonomy was regarding the development of the children. Although the taxonomy has been described as a final product in very general terms, questions needed to be asked regarding its development as follows:

* Do some strategies change with age, so becoming qualitatively different later ?

* Do some strategies remain unchanged in nature but become more elaborate?

* Do certain strategies decline as children get older or emerge, not having existed earlier?

To illustrate the findings the following section presents detailed comparisons of D&T tasks undertaken by groups of children as they grow older in order to examine children's strategies at different points in time.

6.1 Age Related Comparisons

Two sets of comparisons are given here. The first analyses strategy variation during the first year of school, showing how children's strategies develop from their first D&T tasks to the end of their Reception year. The second comparisons show strategy variation from Year 1 to Year 2. At the end of this chapter these two comparisons will be collated to summarise children's strategy development in one school over the whole of the key stage.

The first comparison looks at the strategies of three reception groups at Gorden Park, designing and making Greetings cards in December, four months after entering school, and then making invitations at the end of the reception class (Tables 17a,17b,18).

Table 17a. Varying Aspects of Children's Strategies after 4 months in the reception class: Gorden Park Group. Task: Greetings cards.

Strategies:after 4 months in school	Example
Personalisation * Some direct reflection on similar previous tasks. * A degree of helplessness within the group. * Little confidence in task related concept building.	C1: We made cards before. C2: You can put birds on them. C3: But only robins. C4: Angels Fly. C2: I think you can put them on a Christmas card. C!: Oh look you can put food on it. (looking at commercial card in surprise)
Negotiation: * Revolved around taking product home. Worked within checking what was 'allowed'	C1: Could we take them home? C2: Give them to your Mum? C3: Your Gran?
Identifying needs * Some watching and waiting for guidance. * Short list of identified needs produced by the group. * Some looking ahead to possible requirements later in the session. *Already some group consensus regarding order of procedure.	C: I haven't got any card (children waiting to be handed material that is in front of them) C1: Can we have a pink card? C2: I want an orange one. C3: What about pencils? C1: I'll go and get some. C1: First we got a card and we drawed a picture on a card and we... C2: We coloured it. C3: We put sticky on it..

Table 17a (continued) Varying Aspects of Children's Strategies after 4 months in the reception class: Gorden Park Group. Task: Greetings cards

Strategies: after 4 months in school	Example
Focusing on materials * Focus on all resources in turn. * Some conserving of resources	C1: I need the glitter. It's very shiny and sparkly C2: I need the blue glitter. C3: Put it back in the tube (using lid of tube to scoop up spare glitter and put it back) C1: Are these new? (replacing felt tip lids)
Talking Self Through * Revolved around skills and procedures. * Began to help planning	C1: I'm drawing an angel...there and an arm.. Oh I've done it wrong. C2: There and now I'll decorate it with glitter...ahh glitter. C3: Now what do I need to do? I know, make some wings.
Showing and evaluating * Openly showed and shared their work. * Some short comments about peers work. *.Some giving up or changing direction..	C1: Look! my angel.I've done my angel C2: That's good. C3: Don't look like an angel to me! C1: Angels are too hard for me. (giving up and drawing Christmas tree instead) C2: They're not too hard for me. C3: You just have to get used to them, thats all
Identifying difficulties, Tackling obstacles, Sharing and cooperating * Some difficulties with joining skills but beginning to draw more on group experience. * Difficulties more likely to be identified and tackled alone but a little peer scaffolding undertaken, * Group begin to act together to correct his mistakes.	C1: Oh look! It's all messy (put on too much glue) C2: Wipe it off. C3: Anyone got a tissue? C2: I know you can get a new piece of card. C1: Oh! I've done it wrong. C2: Rub it out C3: Anyone got a rubber for her ?

Table 17b. Varying Aspects of Children's Strategies at the end of the reception class: Gorden Park Groups. Task: Invitatation cards.

Strategies: end of Year R	Example
Personalisation * More direct reflection on similar previous tasks. * A degree of competition within the group. * Greater confidence in task related concept building.	C1: I remember, we made cards. C2: Are we going to make Christmas cards again? C3: No, birthday cards or Mother's' Day? R: Invitations to a Teddy Bears' Picnic. C4: I have the story of when teddy bears go on a picnic. And a reading book. C2: And I know the song. C1: My friend's been to a Teddy bears' museum where you get all, where you get all the little foods and little plates.
Negotiation * Revolved more around materials and procedures.	C1: I want to do mine like a bear shape. Can we do a shaped card? C2: What kind of pictures could we put on the fron,t then? C3: Teddies. Sitting there eating their honey.
Identifying needs * More direct requests but still some watching and waiting for guidance. * Much longer list of identified needs produced by the group. * They looked further ahead to possible requirements later in the session. * Growing group consensus regarding order of procedure.	R: Right, what do you want to do first? (children waiting as if for instructions) C1: Paper! Right, I'll get it... C2: Some pens and some paper we need C3: And what do we need these three pots for. C1: Glue, glue! C4: Hey, I'm going to have some glitter! I'm going to have this fur too. C5: Shall we decorate the picture and then we can open inside? C1: Right, shall we start? We can decorate this then do the writing.

Table 17b.(continued) Varying Aspects of Children's Strategies at the end of the reception class: Gorden Park Groups.Task: Invitation cards.

Strategies: end of Year R	Example
Focusing on materials * In depth focus now only on new resources provided. * Focus now in the form of self structured play.	C1: Hey, I'm an animal. (puts fur fabric on chest) C2: I'm a lady, I'm a lady. (puts it on head) C3: Ah, lovely, lovely, lovely! (stroking fur) C1: I love honey. (pretending to be a bear)
Talking Self Through * Still revolved around skills and procedures. * Aided planning more.	C1: I'm going to do an invitation flat (not folding but smoothing out the card) C2: I think I'll fold it. (folding carefully) C3: Another two legs, I shall put another two legs on him....there.....done it. C4: I'm going to draw a picture of a teddy bear
Showing and evaluating * Continued to openly show and share their work. * More direct but kind in comments about peers work. * Depreciate own work to gain reassurance.	C1: Helen's an artist! C2: Have you finished your drawing? C3 That's my stupid one (showing drawing) C4: Let's have a look . That's good. C5: That's jolly good. C3: Everyone will say it's stupid.
Identifying difficulties, Tackling obstacles, Sharing and cooperating. * Continue to have difficulties with joining skills but can now draw more on group experience. * Difficulties more likely to be tackled by group and peer scaffolding undertaken, * Group take responsibility for members action and act to protect him from authority and correct his mistakes.	C1: What a mess you've made. You shouldn't have done that.(Orin used too much glue) C2: You should have done that and put some over there.(spread the glue out more) C3: Chris's been to get the glue sticks and scissors. (Chris returns with both) C2: Here we are. Look, like that..... put glue on there.(instructs Orin) C1: You just have to go, look put it like that. He did a little accident here.(speaks for him to teacher as Orin has also spilt glue on the floor) C2: Look like that.(Nikki demonstrates kindly)

Table 18. Comparing Aspects of Children's Strategies during their first year in school: Gorden Park School

Strategies after 4 months:	Strategies at end of the year.
Personalisation * Some direct reflection on similar tasks at home and outside school. * A degree of helplessness within the group. * Little confidence in task related ideas.	* More direct personalisation and reflection on similar tasks in school. * A degree of competition within the group. * Greater confidence in task related ideas.
Negotiation: * Revolved around taking product home.Worked within checking what was 'allowed'.	* Revolved more around materials and procedure.
Identifying needs * Some watching and waiting for guidance. * Short list of identified needs produced by the group. * Some looking ahead to possible requirements later in the session. * Already some group consensus regarding order of procedure.	* More direct requests but still some watching and waiting for guidance. * Much longer list of identified needs. * Looked further ahead to possible requirements later in session. * Growing group consensus regarding order of procedure.
Focusing on materials * Focus on all resources in turn. *Some conserving of resources	* Focus now on new resources through self structured play. * Some conserving where material valued.
Talking Self Through * Revolved around skills and procedures. * Began to help planning	* Still much in evidence revolving around skills. * Some very short term planning.
Showing and evaluating * Openly showed and shared work. * Short comments about peers work. *.Some giving up.	* Continue to show and share openly. * More direct comments about peers work. * Depreciate own work to gain reassurance.
Identifying difficulties, Tackling obstacles,Sharing and cooperating. * Some difficulties with joining skills but beginning to draw more on group experience. * Difficulties more likely to be identified and tackled alone but a little peer scaffolding undertaken, * Group begin to act together to correct his mistakes.	* Continue to have difficulty with joining skills but begin to draw on group experience. * Difficulties more likely to be tackled by the group. Some peer scaffolding but few children worked together continually. * Group take responsibility for members action and act to protect him from authority and correct his mistakes.

6.2 Aspects Of Initial Strategy Variation

During the Reception Year at Gordon Park.

The following short summary of the initial variation in children's strategies during their first year in school will be developed when strategy variation over the whole key stage is presented at the end of this chapter.

Personalisation

The results of the analysis of reception children making Greetings cards, nearly four months after entering school, and the same reception children doing a similar task at the end of their first year, indicated that they used the same types of strategies in the same general sequence, but certain subtle variations in detail existed within these strategies. Naturally, the children entering school had little experience of similar tasks in school to reflect upon, so they used more *personalisation* from home, but by the end of the year they were able to reflect directly upon similar tasks and experiences in school. A few months after entering school they were still rather confused and 'helpless prone', waiting for the teacher or adult to take the lead in discussion, while by the end of the year when discussing the task of invitations for a teddy bears' picnic, they showed more confidence in task related ideas and were not only proactive, but exhibited a degree of *competition* in their interaction:

R: Who's got a teddy?
C1: Me, me.
C2: Me, I've got more, I've got a load!
C3: I've got four.
C4: I've got two.
C5: I've got ten!
C1: Well, I've got about ninety-nine!
C4: I've got two thousand and fifty.

Negotiation

On first entering school the children tended to try to work within what was 'allowed' in school and did not attempt to push out the boundaries of a task. *Negotiation* centred around personal thoughts such as whether they could take their products home. By the end of the year the children had some idea of what was expected of them and had the confidence to extend their own interests through the task by requesting certain colour materials or extensions of the task. When making Christmas cards in December the group were only mildly interested in evaluating commercial cards and in fact referred to it as 'a waste of time'. Six months later, however, in July they were fascinated by examples of invitations and had the confidence to criticise the type of writing used inside the card:

R: So we need some invitations. I've got some invitations here.
(producing commercial cards)

C3: I've got some invitations at home!

C2: That's a reply. (pointing to separate reply card provided with the invitation)

R: Yes, well done. That's a reply card.

C4: 'Dear somebody, you're invited to my party at .... on....'. (reads card)

C5: Hah, hah, (children read card and laugh at cloze procedure)

C6: 'Dear something, ...I will / I will not come'.....(reading card)

C3: That's funny, that is...

Focus on Materials

When making Christmas cards in December the groups *identified a short list of needs* such as pencils and card, but *focused in depth on all the resources* in turn, taking time out from making to explore the properties of glitter, sequins, tinsel and even balloons in investigative play. By the end of the year the group's self structured play was limited to only a few new resources. Early interest in conserving materials was maintained later in the year.

At the end of the year the children also continued to use self directed speech to *talk themselves through* sub-tasks but as the children grew older they used this to think and plan ahead much more. They had a clearer idea of the order of procedure when making a Greetings card and moved from 'first we fold it, then we decorate it' in December, to 'folding and drawing a picture, decorating the picture and writing inside the card', in July. Throughout the task the older group organised their own order of procedure. This progression of activity was spontaneous and was not openly discussed, but seemed to be implicitly agreed by all. This entailed first getting pencils, then folding card or using it flat, drawing on the front, writing at the top of the drawing, then decorating the picture with materials provided, and finally writing inside or on the back of the invitation. This complex procedure compared to the simple order of events described by the same children six months earlier. The children did not ask about the order of events but still felt the need to wait for reassurance or check if they were allowed to proceed.

Showing and Evaluating

During *showing and evaluating,* which happened throughout the sessions, both the groups showed and shared openly. However, as children grew older their comments became less about personal likes and dislikes and more directly related to the work of peers. Individuals seemed less inclined to give up on tasks as they had done in earlier sessions, but showed some dissatisfaction with their work by depreciating it to other's in order to gain reassurance and confidence to proceed.

The youngest groups *identified difficulty with joining materials*, and by the end of the year still had problems managing resources such as glue. But the youngest children tended to work alone, and were just beginning to use peer scaffolding although they sometimes helped each other physically to tackle problems. *Sharing and cooperating* strategies were seen to evolve in the first year of school and by the end of the reception year the children were beginning to work together as a group much more, and were more direct and frank in communication and more confident in their interaction. However, *pretend panic* and squabbling happened towards the end of the sessions revolving around materials that were highly prized by the group, such as glitter, sequins and glass beads:

C1: Not again, oh no.
C2: You can't have all of them.
C3: Not all of them. (glass beads)
C4: Get them away from him.
C1: We're not getting on.
C2: Can we carry on and finish after playtime?

Despite this, in general the group had moved from working alone to beginning to work together, exchanging occasional reassurance, physical help and ideas concerning skills and procedure. This was one of the most noticeable features of their changing strategies as they began to work together with greater confidence. They began discussing and negotiating the task, working with and conserving the materials, and planning ahead through self directed speech and interaction with peers.

Same children compared from Year 1 to Year 2

The second part of this comparison stays in the first school and traces the same groups of children engaged in two more tasks but this time focusing on the use of hard materials. At the end of Year 1, the groups at Gorden Park designed and made model buildings as part of a scheme of work related to the erection of a new infant block on the site, and at the end of Year 2 they created rain forest shelters. The following tables chart varying aspects of their strategies over this time (Tables 19a,19b, 20).

Table 19a Varying Aspects of Children's Strategies at the end of the Y1: Gorden Park Group. Task: Model Buildings

Strategies at end of Y1	Example
Personalisation * Groups reflected upon previous tasks and linked them with present task. Focus on home and school. * Remembered previous tasks to make sense of the role of researcher. * More competition. * Growing confidence in task related ideas.	C1: My brother made a box in woodwork class. C2: Mine did too. First he did the cutting but he didn't stick it, he used nails and a hammer. C1: We remember you, we made cards last time with you. C2: We can make lots of different buildings
Negotiation. * Centred around negotiating the boundaries of the task. * Groups asked what was 'allowed'. * Children changed or re-posed the task according to their own interests. * Copying denounced.	C1: I'm going to make a church so that I can use a saw for the point. C2: I'm going to make a dolls house for my dolls',but you're not to copy. C3: A swimming pool? C4:Are we allowed to make a newsagent's?
Identifying Needs * Chose and gathered own resources. Less watching and waiting, group more proactive. * Longer list of identified needs and some realisation of support obtainable from peers as human resource. * Groups identified a need to practice before using tools. * Conserved materials which they valued for other members of the group. * Awareness of group consensus regarding procedure.	C1: I want to use lots of wood. (choosing wood) C2: I need a big block for the foundations. C3: Some sellotape. C4: I need string and cardboard boxes. We could help each other by holding the pieces. C1: How do we cut the wood? C2: We need practice first. C!: Look,don't use all that string someone else might need it. C2: First we get all the stuff, then we start with the base and build it up with wood. C3: And some card. Then put on the roof.

Table 19a continued Varying Aspects of Children's Strategies at the end of the Y1: Gorden Park Group. Task: Model Buildings

Strategies at end of Y1	Example
Focus on materials * Groups focus more selectively. * Gender issues surrounding tools. * Groups saw school tools as outdated technology. **Talking self through** * Talking through began to be aimed at other's as well as self. More reflective now. **Showing and evaluating** * Cooperation valued. Some children ask to work in pairs. * Showing one to one throughout the session and open evaluation. * Evaluation reflected personal preferences but rarely the product criteria. **Identifying Difficulties,Tackling obstacles,Sharing and cooperating.** * Still struggling with making skills and techniques which depended on knowledge and understanding of structures and mechanisms. Sometimes reluctant to accept advice or ask for help. * Children began to be aware of positive aspects of cooperation. This usually physical. Still quite forgiving of each other's mistakes. * Planned intuitively as they worked and talked but only the immediate step and never far ahead.	C1: It's a bit tricky job for a girl actually. (sawing) C2: We don't need to use the drill till we need a hole. C1: Why don't we use a proper saw? C2: It'd be good if we had a proper one,you could go schuzz! (electric saw) C1: We're putting the cardboard boxes in cos we've got to add rooms on now we've done the bottom. C1: Can us two work in partners? C2: We can share it and hold it together. C1: Oh my door's come off. C2: Oh poor you. C3: Anyway I like it better. C1: It's going to fall down...my house! C2: Don't take that (support) away otherwise it will just melt apart.... it'll all fall forward. C1: Don't drill right through the wood or you'll have a hole in the table. C2: But I want a hole right through. C1: You've got to wind it round and hold the top and hold the piece of wood. C2: You need three hands. C3: He's got three hands because his friend is helping him. Seems easy now!

Table 19b. Varying Aspects of Children's Strategies at the end of Y2, Gorden Park: Task: Rain Forest Shelters.

Strategies: end of Year 2	Example
Personalisation * Little direct personalisation. * Confident in immediately understanding the task no need for concept building. **Negotiation** * Could describe the boundaries of the task clearly to children from another class. * Negotiated working together rather than the task itself. * Took it for granted that they had a wide frame in which to work. **Identifying needs** * Used previous experience of materials to assess present needs.. Now requested resources not on display and improvised if not available. . * Human resources needs included: requests for specific support from peers, and specific expertise from adults. * They saw the need to learn new techniques and practise for future sessions. * Extended consensus regarding future procedure.	R: If you were in a rain forest, what kind of shelter would you need? Who can tell me? C1: A waterproof shelter. C2: Cos it rains a lot in the rain forest. C3: Um. Camouflage. C1: So that no animals can come in. C4: It can be green for hiding. C5: It has to be shady because of the sun. C1: Why are you doing that? (child from another class) C2: Oh cos we're allowed..... C3: About jungles and rain forests. You see those houses up there? They're like tree camps. So we're the next group to do it. And so we want to, we're making what we'd like to live in in the rain forest. C4: Will we be allowed to work in partners? .. C1: It's a drill. There you are, you do it. . C2: You can do the two of them (holes) while I carry on doing this. C1: Not too hard, not too hard. There you are, you do it. (encourages friend) C2: I'll hold it. Is this right Mrs Roden? R: Don't press. Just turn..... gently. C2: Goes right through the table, doesn't it? (the clamp to hold the bench hook) R: No, why do you think the clamp is there? C1: Cos holds that, so it stays safe.We can do this in Mrs Holmes lesson now.

Table 19b.continued_ Varying Aspects of Children's Strategies at the end of Y2 : Gorden Park Group. Task: Rain Forest Shelters.

Strategies: end of Year 2	Example
Focusing on materials * Focused in depth on tools, function and techniques,especially cutting , measuring and marking. * Could reflect upon and pass previous adult scaffolding regarding skills, on to peers a year later. **Talking Self Through** * Very little now. **Showing and evaluating** * Now discussed the criteria for designing and making throughout the session.,but could still occasionally forget. * Evaluated product with peers and adults at the end and modified accordingly. * Some awareness of own learning and cooperative development **Identifying difficulties, Tackling obstacles, Sharing and cooperating.** * Group more confident in use of tools and materials. * Cooperation valued . Some children asked to work in pairs. * Tackling obstacles together now of an intellectual as well as physical nature. Pairs made joint decisions and planned together in situ.	C1: Softest cheese, pretend it's cheese. And do it as soft as you like. (sawing) R: What are you telling her to do Zoe? C1: Try and, um, pretend it's cheese and ..... R: How do you know to pretend it's cheese? C1: Cos you told me last time and I..... R: Oh that was a year ago. And that's quite right because that's what I always say. I say pretend it's cheese. How clever of you. C1: Zoe ? You know the water hole here. Shall I cover this bit as animals might come through? C2: Yes. Thats good! C1: What about the rain? C2: See that house, the tree house there with the ramp. I wouldn't want to live in there if I had to the rain would make it hard to get in, cos I'd rather have a door. C1: Sawing through wood. Takes a long time. C2: I'll do it. (takes over from partner) C1: That's done. C2: Yeah and now we need to mark with pencil (so that the supports are the same length). C1: Right, where's that pencil ? C2: Oh can I just do two of the markings? Pencil.(holds out hand) C1: So, wait, wait. So this must be the middle then..... We need the other rod. C2: Yeah I think we will. C1: Right so this is like that. (the same length) C2: And remember Trina I've just cut one.

Table 20. Comparing Aspects of Children's Strategies during their second and third year in school: Gordon Park School

Strategies at end of Y1:	**Strategies at end of Y2.**
Personalisation * Groups reflected upon previous tasks and linked them with present task.Focus on home and school.. * Remembered previous tasks to make sense of the role of researcher * More competition. * Growing confidence in task related ideas.	* Little direct personalisation. * Confident in immediately understanding the task not so much need for concept building concerning task. * Most competition.
Negotiation. * Centred around negotiating the boundaries of the task. * Groups asked what was 'allowed' * Children changed or re-posed the task according to their own interests. * Copying denounced	* Could describe the boundaries of the task clearly to children from another class. * Negotiated working together rather than the task itself. * Took it for granted that they had a wide frame in which to work. * Copying still unacceptable
Identifying Needs * Chose and gathered own resources. Less watching and waiting, group more proactive. * Longer list of identified needs and some realisation of support obtainable from peers as human resource. * Groups identified a need to practise before using tools. * Conserved materials which they valued for other members of the group. * Awareness of group consensus regarding procedure	* Used previous experience of materials to assess present needs.. Now requested resources not on display and improvised if not available. . * Human resources needs included: requests for specific support from peers, and specific expertise from adults. * They saw the need to learn new techniques and practise for future sessions. * Extended consensus regarding future procedure.

Table 20.continued Comparing Aspects of Children's Strategies during their second and third year in school

Strategies at end of Y1:	**Strategies at end of Y2.**
Focus on materials * Groups focus more selectively. * Gender issues surrounding tools. * Groups saw school tools as outdated technology.	* Focused in depth on tools, function and techniques, especially cutting, measuring and marking. * Could reflect upon and pass previous adult scaffolding regarding skills, on to peers a year later. Saw school tools as historical technology
Talking self through * Talking through began to be aimed at other's as well as self. More reflective now.	* Very little now. Discussed work with friends and periods of silent concentration.
Showing and evaluating * Cooperation valued . Some children ask to work in pairs. * Showing one to one throughout the session and open evaluation. * Evaluation reflected personal preferences but rarely the product criteria.	*Less showing but discussed the criteria for designing and making throughout the session but could still occasionally forget. *Evaluated product with peers and adults at the end and modified. More critical * Some awareness of own learning and cooperative development
Identifying Difficulties, Tackling obstacles, Sharing and cooperating. * Still struggling with making skills and techniques which depended on knowledge and understanding of structures and mechanisms. Sometimes reluctant to accept advice or ask for help. * Children began to be aware of positive aspects of cooperation. This usually physical. Still quite forgiving of each other's mistakes. * Planned intuitively as they worked and talked but only the immediate step and never far ahead.	* Group more confident in use of tools and materials. Now had greater experience. Employed more help seeking from adults and peers concerning skills. * Cooperation valued. Some children asked to work in pairs. Not sure if they were allowed to work across pairs. other's still preferred to work alone. * Tackling obstacles together now of an intellectual as well as physical nature. Pairs made joint decisions and planned together in situ.

6.3 Aspects of Further Strategy Variation

From Year 1 to Year 2 at Gorden Park

Personalisation

Again the results of the same groups of children doing a similar task with the same type of resources a year later, indicated the same general strategies but with certain variations from Year 1 to Year 2. At the end of Year 1 the children were still personalising, linking home and school tasks, but in Year 2 they did not use *personalisation* to help them make sense of the task, because they immediately understood and expanded upon the concept of rain forest shelters in response to the researcher's questions. In Year 2 they continued to discuss the criteria for designing and making the shelter throughout the activity, and not only during the introduction, as in Year 1. However, occasionally the older children still forgot the task criteria altogether and reverted to a little personalisation when they became confused between their own experiences in the New Forest in Britain and the Amazon rain forest, as in the following exchange:

C1: It's all green, the New Forest, isn't it?
C2: Yeah, I went there.
C1: My mum said.
C3: Trina went there.
C4: I know, I'm going there for my holidays.
C2: And the wild wolf came up and they're quite tame even though they're wild and there's baby donkeys and the're are mother donkeys.
C1: These are actually wild ones here. (in the rain forest)
C1: Oh.

Negotiation

Negotiation centred around the boundaries of the task in Year 1 when the group still felt the need to check what they were allowed to do. At that time the children were beginning to *negotiate* the boundaries of the task by asking to make an underground shelter or dug-out like a soldier they had seen on the news, rather than a conventional building. They asked:

C1: Are you allowed to make a newsagent's?
C2: No, that's boring.
C3: Wait a minute, wait a minute..a hide-out I saw it on the news ....it's a dug-out..... but you can still live in it.
C4: A shoe shop?
R: A shoe shop, and I suppose you could make a dug-out but its stretching it a bit. (the task frame)

Here one child had *re-posed or extended the frame* of the original D&T task to suit his personal wants and needs. Later in the session he *talked himself through* what he has done:

> C3: I started at the top and ... what I did... yesterday on the news I saw a soldier's dug-out... I'm making a little hideout.... where I can dig in... the other children don't have a hide-out... I'm safe in here... you're leaving.

In contrast, by the end of Year 2 the children could describe the task boundaries of the task clearly to other groups and knew what they were allowed to make. But although they were confident about what they were allowed to make they were unsure of how far they were allowed to work together. By Year 2, they were unsure about being allowed to collaborate and *negotiate*. This may have arisen from their attitudes to *copying*, which was still socially unacceptable within the group:

> C2: I'm not copying you, I'm just watching. (child watches the way card is folded by another to make a tent)
> C3: You're not copying. (warning)

Identifying Needs, and Practice and Planning

The change in aspects of children's strategies from Year 1 to Year 2 when *identifying needs* was interesting. The Year 1 groups were more proactive than they had been in the reception year and now helped themselves freely to the materials available. By Year 2 however, the children had experienced a range of tools and materials both in and out of schoo,l such as double sided sellotape, and requested resources that were not on display or improvised if these were not available. The Year 1 children tentatively asked to practise with tools before beginning the task and started to conserve materials such as string for other group members. At Year 2, the children took it for granted that practice was needed and went so far as to save materials for future D&T sessions.

In Year 1 the children talked about what to do next when the need arose but did not plan beyond this. The Y2 children planned ahead together in situ but not formally on paper. Like the girls in the following passage, they saved materials for later and planned physically in this way:

> C1: I know, this could be the back of the house, that could be the bedroom and then that could be the outside shelter there, OK?
> C2: Make two beds, one for you and one for me.
> C1: Do we need any um?(net)
> C2: Well, we might do, we might need a little bit of that. You can cut it. Yeah, cut it a bit 'cos.

C1: Ah, now.

C2: You can, you can have that net on the top against insects. (in the rain forest)

At Year 2 the children were also aware of the need to *plan* their time. Jason asked:

C1: What happens if we don't finish it today?

R: Well I think we've got to try hard to finish it today, actually. Can you do that?

C1: Yes.

R: Can you work really hard?

C2: Now I put this on here.

C3: Take a bit of that then, and perhaps not use this because it will take too long now.

C1: Yes.

Focusing on Tools and Materials

While *focusing on materials*, both Year 1 and Year 2 groups viewed tools and their use in interesting ways. At Year 1 the boys thought that using tools was even harder for girls and they were surprised that girls were included in the group at all, but the girls professed it to be easy:

C1: We got girls doing them? (working with tools, boy speaking)

R: Sorry?

C2: Not girls! My brother's got them tools. (boy speaking)

C3: Umm, easy! (girl speaking)

C4: She can't!, she's a girl. (boy speaking)

C1: It's a bit tricky job for a girl, actually! (boy speaking)

Some children in Year 1 were surprised that tools had a place at all in the classroom and asked, 'What are all these doing in school?' An interesting and very valid view of child-size tools was taken by the group. They seemed to feel that 'real' tools should be provided and were rather disdainful of the small junior version. They saw them as outdated technology. For example, one child said that he enjoyed sawing 'with a real saw... not one of those saws... the other sort.' Another child asked:

C1: Why don't you use a proper one? (saw)

C2: A long one.

C1: Which is the next one? (tries another hacksaw)

C3: It's a bit easier, I think.

C1: It'd be good if you got a proper one, you could go schuzzz! (electric saw)

A year later in Year 2 the children's perception of a junior hand drill took on a more specific historical focus. Children asked if school tools were the ones they used 'in the olden days', and they were able to analyse the materials used in commercial production:

C1: Is this what they used in the olden days? (pointing to drill)
R: What, that drill? What, why do you say that? Because it's....?
C2: Yeah, 'cos it's, it's not electric.
R: It's not electric no. It's not an electric drill.
C1: I wouldn't think they'd have even this drill then. (it looks so old)
C3: That could have been.
C2: It's metal.
C3: Is it?
C4: Yeah, it's metal.
C3: Oh yeah.
C1: And this is wood.
C3: Everything's metal except the handle.

Sharing and Cooperating

There was a marked variation in aspects of group *sharing and cooperative* strategies from Year 1 to Year 2. Children in Year 1 were just beginning to appreciate cooperation, while in Year 2 they were requesting to work with a partner and extending work across pairs. Starting at the end of Year 1, the group were beginning to appreciate the usefulness of human resources in the form of their peers. The Year 1 group discussed together making a drawbridge for their building and began to think about physical help from friends. They saw it as the usefulness of having 'three hands':

C1: You've (I've) got to wind the string round and hold the top and hold the piece of wood too.
C 2: You need three hands.
C3: He's got three hands.
C4: Because his friend is helping him. Seems easy now.

By the end of Year 2, at seven years old, some of the children asked to work with a partner at the outset of the task and worked together well but other's were fiercely independent:

C1: Will you be allowed to work in partners?
R: If you would like to work in partners you're allowed to. (some nod and some shake their heads)
C2: I 'm with Zoe.

C1: And I'm with Trina.

R: Right.

C3: And I'm with you.

C4: No, I'm not. I'm with myself.

Moreover, in Year 2 at seven years old the pairs seemed aware of their own evolving *sharing and cooperative strategies:*

C1: Zoe and me are getting on quite well.

R: You are getting on quite well.

C2: That's good.

C3: I'm getting on quite well.

C1: On your own.

C2: Mrs Williams, do you like our, um, paper trees?

Teacher: That's nice.

C1: Yes, we're making two beds to go in there.

Teacher: Oh, are you?

C2: I'm making a bed.

C1: We're making them, then we're making a shelter here so we can sit under it to have our lunch. We're working nicely together.

But these older children were still able to employ *help-seeking strategies* and request physical help from adults. Here the girls had found difficulty in cutting fabric for two bed covers but had marked the place for the researcher to cut it for them:

C1: Can you do this?

R: What?

C1: That. Cut it at the orange marking. (the fabric where they had marked it)

R: You want me to cut, where the orange mark is?

C2: Cos we're doing a bed, and we want the, um, the same one. (bed cover)

R: Ah, the same size you mean?

C1: Yeah.

C2: Same length.

R: Did you, did you mark it for me there, then?

C1: Yes.

Identifying Difficulties and Tackling Obstacles

The group moved towards more confidence in problem solving from Year 1 to Year 2. The children at Year 1 began to *identify difficulties* in working with hard materials. They encountered problems to do with knowledge and understanding of structure and stability when creating buildings but were not always sure how to tackle them:

C1: How am I going to get the bits coming up? (supports for the roof)
R: How tall do you want it?
C1: About...this high(shows with hand)
R: Right... careful...now (walls about to collapse)
C3: Oh! It's fallen over.

While Natasha, at Year 2, was confident and tackled her problem through previous knowledge of joining material and requested a type of sellotape not on display:

C1: Have you got any double sided tape?
R: No, I haven't got any double sided sellotape.
C2: What's double sided sellotape?
C1: Sellotape? It's got two sticky, one on each side.
C2: Where's the ordinary tape?
C1: The tape? I don't know.
C2: 'You are my sunshine, my only sunshine.You make me happy..'. (sings to canopy)
C1: Oh, this sellotape's no good. (it's single sided and not strong enough)

In Year 1 the children lacked experience of tools and materials but by Year 2 they had learnt to improvise as well as request new materials and when *tackling obstacles,* stability was approached creatively:

R: How are you making it stand up, then?
C1: Oh, I'm cutting the bottom in little snips. (at the bottom of the roll)
C2: I know, but you could do the other side.
C3: Make sure that side doesn't fall.
C2: Will this glue come out?
C1: You might have to just wipe that all off and then you can scrape that. (glue from the nozzle)
C2: Mind, but we need quite a lot and then it won't dry up so quickly.
C1: No, I know, but then it's going to spoil the edge.

At Year 2 problems to do with strength and weigh-bearing associated with stability were also tackled with confidence. Here they discuss appropriate supports of the roof of a shelter:

C1: But they're not very thick Trina. They can't hold things, these can hold things, they can't. (comparing card rolls with wood sticks for supporting the roof)
C2: OK then Mr stick, I'll put you there if anyone else wants you.

Showing and Evaluating

Variation in aspects of the children's *showing and evaluating* strategies was particularly noticeable here. In Year 1 this normally happened one-child-to-one, and occurred throughout the session at a constant level. In Year 2 there was less *showing*, or offering work for *evaluation* by peers, and some evaluating throughout, but in general evaluation occurred towards the end of the session but was unasked for. Despite this children were beginning to respond, especially to peer evaluation to modify their work. Evaluation was of three types now; evaluating with peers in twos or threes, evaluating with the researcher, and shared evaluation with a larger group and sometimes the researcher as well. Here are some interesting examples. First evaluation with peers:

Evaluation with peers: Trina, Zoe and Jason

C1: Are you making a tree house?
C2: Yes.
C3: I made that bit.
C2: When we get the green we're going to make some little plants growing.
C1: Oh plants growing too, that's lovely.
C3: There's one done. (shows flower)
C4: Making the plants? Like that, Jason. With felt tip?
C2: Yes.
C3: Now here's the fire.It's going to be cozy.
C1: What's that for? (cot)
C2: A baby.
C4: Soft sleeping bag. (peer feels the fabric)
C1: You made a table.
C5: Wayne's got a really good idea.....Trampoline.
C2: Yeah, let's make a trampoline.
C5: For to go up..... we can bounce up to the tree house.

Shared evaluation with researcher, child and peers: Jason's model

R: Come and tell me all about it. Come here. What have we got? You've got.....
C1: That's an axe. That's for knocking down doors.
C2: That's his jumper.

C1: That's his gun.

R: And that's a gun. So all of those things he's going to need, isn't he?

C2: And that's him.

R: Oh there he is, there he is, I see. You've drawn him there. Right.

C1: And that's the handle to open the door, mm.

C2: Pieces of bush to make a camouflage.

C1: Bird house.

R: Bird house. And a...?

C2: Dog kennel, and this for letters...

R: A letter box, yes. And a...?

C3: Look, look!

C2: Lake.

C3: Zoe, Zoe, look!

C4: The mat that says welcome on. Oh and something on the front door. What does it say there?

C1: Keep out.

R: 'Keep out' on the front door! My goodness! I'd quite like to move into your house, Jason. Would you like to move in? Yes? So, anything else? Or is it finished?

C2: It's finished.

Peer Evaluation: Dominic's model

Peer evaluation seemed to be more effective in terms of modification but was sometimes quite brutal. Here the girls took Dominic to task:

C1: Dominic, you haven't finished. (girls very angry with him)

C2: I have finished. (Dominic)

C1: It don't look like it! (teacher-like)

C2: Why don't it look like it?

C3: Cos it doesn't.

C2: What's wrong with it?

C1: Furniture...none! (pointing hard)

C3: Yeah, there.

C2: Where, here? (Dominic points to inside his tent)

C1: Yeah.

C3: You can't do it there. (put the furniture outside the tent) Everything else is inside the tent.

C2: The shelf isn't.

C4: Well, can't you make something like Jason's? Look. Come over here. Look, I'll show you what he's done at the front. (girls drag Dominic to look at Jason's work)

C4: It says welcome, couldn't you do anything like that?

C2: You think I ought to mark the door?

C3: We've got double sided sellotape now.

C4: Um.

C1: ... there isn't anything you can do, Dominic!.

C3: Anything!...(girls move off shaking their heads and rolling their eyes)

A little later Dominic had responded by modifying his tent:

C1: I've done it.

R: Dominic?

C1: Done it.

R: What have you done, Dominic?

C1: I've put, two, two, um, things...bars... there, so animals can't get in.

R: That's it.

C2: Best to get that in so you can be safe.

C1: I've done it.

But at Year 2 peer evaluation was often positive too. Paul praised Dominic's skills but also provided a slight 'send up' of the researcher's methodology here:

C1: That's sensible, Dominic. That's sensible. Dominic's being sensible, he's folded that so he doesn't have to do it very thin.(stick a thin edge on to the base)

R: My goodness, that is sensible, Dominic, you've folded back the bottom, haven't you? Just to make the tent like that. You've folded the bottom back and stuck it on.

C2: Oh camera time, Dominic!

R: It is camera time. Because he's done a good job. (Dominic poses for a photo')

C2: Right, carry on.

6.4 Collating the Age Related Comparisons for the First School

These first comparisons demonstrate age dependent aspects of strategies for the same children in Gorden Park School during the reception class, and from the end of Year 1 to the end of Year 2. The findings show that children's strategies may differ with age, and they provide evidence of variation in group strategic action over time. The information from the two comparisons was collated in order to chart the variation in aspects of the group strategies over Key Stage 1 (Table 21).

Table 21 Aspects of Strategy Variation over Key Stage 1: for groups at Gorden Park School

End of YR	End of Y1	End of Y2
Personalisation * Much personal reflection on similar experiences outside school. * An emerging degree of competition within the groups. * Groups needed to concept build in relation to the task.	* Groups reflected upon previous tasks and linked them with present task. * Remembered previous tasks to make sense of the role of researcher * More competition. * Growing confidence in task related concept building.	* Groups needed little direct personalisation to relate to task. * They were confident in immediately understanding the task and transferred knowledge from other subjects. * Most competition. * No need for concept building.
Negotiation: * Revolved around procedures and organisation. * Materials, tools and colour an issue. * Copying awareness	* Centred around negotiating the boundaries of the task. * Groups asked what was 'allowed'. * Children changed or re-posed the task according to their own interests. * Copying denounced.	* Groups could describe the boundaries of the task clearly to children from another class. * Took it for granted that they had a wide frame in which to work as task not prescribed. * Negotiated working together rather than the task itself. * Copying still unacceptable
Identifying needs * Some direct requests but still some watching and waiting for guidance. * Growing list of identified needs produced. * Groups began to look ahead to possible requirements later in the session.Began to conserve attractive materials. * Emerging group consensus regarding order of procedure.	* Chose and gathered own resources. Less watching and waiting, group more proactive. * Longer list of identified needs and some realisation of support obtainable from peers as human resource. * Groups identified a need to practise before using tools. * Conserved materials which they valued for other members of the group. *Awareness of group consensus regarding procedure	* Groups used previous experience of materials to assess present needs. Now requested resources not on display and improvised if not available. . * Human resources needs included requests for specific support from peers, and expertise from adults. * They saw the need to learn new skills,practise and conserve materials for future sessions. * Extended consensus regarding future procedure.

Table 21 continued Aspects of Strategy Variation over Key Stage 1: for groups at Gorden Park School

End of YR	End of Y1	End of Y2
Focus on materials * Groups focus in depth on all materials especially resources that are new to them. * Focus exploratory and often take time for self structured play.	* Groups focus more selectively. * Gender issues surrounding tools. *Groups saw school tools as outdated technology.	* Focused in depth on tools, function and skills, especially cutting, measuring/marking. * Could reflect upon and pass previous adult scaffolding in skills on to peers a year later. * Groups saw school tools as historical technology.
Talking Self Through * Revolved around skills and procedures. * Aided planning.	* Talking through began to be aimed at other's as well as self. More reflective now.	* Very little now. Discussed work with friends and periods of silent concentration.
Showing/evaluating * Group continued to openly show and share their work * Commented on other's work directly but kindly. *Depreciated own work to gain reassurance.	* Cooperation valued . Some children ask to work in pairs. * Showing one to one throughout the session and open evaluation. * Evaluation reflected personal preferences but rarely the product criteria.	* Less Showing but discussed the criteria for designing and making in the session. Could still occasionally forget criteria. * Evaluated products with peers and adults at the end of session and modified them. More critical. * Some awareness of own learning and cooperative development.
Identify difficulties, Tackling obstacles, Sharing and cooperating. * Difficulties with joining skills but began to draw more on group experience. * Children worked alone but difficulties began to be tackled by group and peer scaffolding undertaken, * Group took responsibility for members action and acted to protect him from authority and correct his mistakes.	* Still struggling with making skills and techniques which depended on knowledge and understanding of structures and mechanisms. Sometimes reluctant to accept advice or ask for help. * Children began to be aware of positive aspects of cooperation. This usually physical . Still quite forgiving of each other's mistakes. * Planned intuitively as they worked and talked but only the immediate step and never far ahead.	* Group more confident in use of tools and materials. Now had greater knowledge to support these. Employed more help seeking from adults and peers regarding skills. * Cooperation valued. Some children ask to work in pairs but were not sure if they were 'allowed' to work across pairs. other's still preferred to work alone. * Tackling obstacles together now of an intellectual as well as physical nature. Pairs made joint decisions and planned together through discussion in situ.

6.5 Children's Changing Strategies?

The research questions asked at the beginning of this chapter were as follows:

* Do some strategies change with age, becoming qualitatively different later?
* Do some strategies remain unchanged in nature but become more elaborate?
* Do certain strategies decline as children get older or emerge, not having existed earlier?

The findings demonstrate that aspects of children's strategies vary with age. These findings provide evidence of change or evolution in children's collaborative strategies over time. The results of the analysis of Gorden Park children indicate that they used the same types of strategies, in the same general sequence, but that certain variations or change in use existed due to children's age. This change took various forms. Some strategies changed radically, some declined with age, and some remained unchanged in nature but seemed to evolve to become more elaborate as children moved through Key Stage 1.

Strategies that Changed in Nature

It can be seen that those strategies that changed radically appear to include *negotiation, sharing and cooperating,* and *showing and evaluating.* In the reception class negotiation revolved around external influences and procedures, such as whether the children could take the cards home, and side issues, such as colour of materials, while at Year 1 the focus of negotiation was on the task itself, some children arguing to re-pose or change it to suit themselves. In contrast by Year 2 negotiation looked completely different, focusing on working together with peers (Table 21).

Sharing and cooperating, also looked very different at each end of year. While very young children were sympathetic to each other, they tended to work alone in the reception class. Even at Year 1 help and support was usually of a physical kind. However, cooperation was valued at Year 2, some children requesting to work in pairs, tackling obstacles together through discussion as well as physically (Table 21 continued).

Similarly, *showing and evaluating* changed dramatically from Reception to Year 2. While Reception children openly showed and shared their work, and children sometimes made or received short comments concerning whether they liked each other's work or not, Year 2 groups did not offer work for evaluation at all, but unasked,evaluated each other's work during, and especially towards the end of the D&T session in a critically appropriate way.

Strategies that Declined with Age

It can be seen from the charts that certain strategies actually declined with age. *Personalisation* and *talking to self* are examples of this. *Personalisation* was used extensively by very young children when they first entered schools as a means of making sense of school learning by relating it to personal experience outside school. As children grew older and had more school learning experiences, they were able to relate to these when needing to make sense of new tasks. As they grew in confidence towards Year 2

they could discard personalisation, or maybe not use it so openly, in favour of knowledge from previous school activities and other curriculum areas (Table 21).

Similarly, *talking to self* was used extensively by individuals to systematically talk themselves through tricky procedures in Reception, it was also aimed at friends in Year 1, but was discarded or internalised in Year 2 (Table 21 continued). Many strategies remained unchanged in nature but evolved with age, becoming more elaborate as children grew older. However, strategies did not seem to take the contrary path, that is, they did not seem to emerge from unseen origins, during the key stage.

Strategies that Remained Unchanged but became more Elaborate with Age

It seems that *focusing on materials, identifying wants and needs, identifying difficulties* and *tackling obstacles* evolved with age. Young children in the reception class focused on materials mainly through play, but as they grew older they did this more selectively, exploring only those resources with which they were unfamiliar, so that by the end of the key stage children were investigating in depth the function of certain tools and materials and gaining expertise collaboratively (Table 21 continued).

Identifying wants and *needs,* moved from children unable to think ahead to request the resources they would need, and therefore watching and waiting to see what was provided, to children identifying long lists of resources, choosing and gathering these for themselves, and requesting new materials or improvising. There was a growing awareness of the value of human resources, and a need to draw on past experience, learn new skills, and to conserve certain highly prized resources (Table 21).

Identifying difficulties and *tackling obstacles.* Here children moved from encountering difficulties in working alone, and beginning peer scaffolding to employ basic manipulative skills such as folding and joining, to working together and confidently employing knowledge and skills to tackle their problems. There was also a move from beginning to seek and accept physical help to pooling both physical and intellectual resources at the end of the key stage (Table 21 continued).

6.6 Summary

It is reasonable to ask now whether all the strategies identified in the study conform to the patterns of strategy variation covered by the research questions. So far the findings from the first school indicate that all except one of the strategies of the taxonomy appear to conform to the aspects of variation described above. It is noticeable that *Practice and Planning* does not fit so clearly into the pattern. Some evidence of children wanting to practise existed at Year 1, and children were certainly found to use planning strategies at Year 2, when they were interwoven with other strategies such as *identifying needs* and *identifying difficulties and tackling obstacles* (Table 21 continued). Moreover, the evidence of either practice or planning in the reception groups was elusive. It was necessary to look very closely in the second school at comparisons across the whole key stage to clarify the matter. This is done in the next chapter.

Chapter 7
Age Dependent Variations in the Taxonomy: The Second School

Introduction

A picture of variation in the children's D&T problem solving strategies as they grew older had emerged from the findings in the first school. From these findings there is evidence that:

* Some strategies change with age, becoming qualitatively different later.

* Some strategies remain unchanged in nature but become more elaborate.

* Certain strategies decline as children get older.

* Some strategies may become more complex.

However, was the first school a unique case? Further evidence was needed from another school.

7.1 Further Age Related Comparisons

In the second school it was necessary to look closely at all strategies across the whole key stage in order to gain a clearer picture of strategy variation, and also to look more closely at the type of variation that can be seen in a very complex strategy, that of *Practice and Planning.* This strategy seemed to have aspects that developed in a particularly interesting way as children grew older. Therefore, the next comparison looked at the second school, Waterfields Infants, and compared the very first task of Greetings cards which the children did when they entered school with the very last task they did which was Thank you cards at the end of Year 2 (Chapter 3, Table 8a). The findings are charted below (Tables 22a, 22b).

Table 22a . Varying Aspects of Children's Strategies after 4 months in the reception class: Waterfields Group. Task: Greetings cards.

Strategies after 4 months in school	Example
Personalisation * Much direct reflection on similar previous tasks at home or outside school. * A degree of helplessness within the group. * Little confidence in task related ideas.	C1: I've got one of these at home. (card) C2: You can put a Father Christmas on. C3: Snow? C4: I like soldiers. I want to do soldiers in the snow. C2: Toys? C1: A horse? C3: No, it's a reindeer.
Negotiation: * The task accepted as given. Limited negotiation revolved around taking product home.	C1: I want to take mine home.(card) C2: Father Christmas comes up the chimney. I can give it to him. Then can you give it to him? C3: Can I have this card to keep?
Identifying needs * Some watching and waiting for guidance. * Short list of identified needs produced by the group, but requested favourite colour regardless of fitness for task. * Some looking ahead to possible requirements later in the session. * Already some group consensus regarding order of procedure.	C1: Right lets make our own. What will we need? C2: Glitter. (seeing tubes of glitter) C3: Paper. C2: I want red. C1: I like blue best. C4: But we have to glue first don't we? C5: Shall we need balloons on my picture?. C1: First we need to fold it. Press it to the sky. (fold the card) C2: Make sure it stands up and doesn't go all wobbly. C3: We draw then. and then glue.

Table 22a (continued). Varying Aspects of Children's Strategies after 4 months in the reception class: Waterfields Group . Task: Greetings cards

Strategies after 4 months in school	Example
Focusing on materials * Focus on all resources in turn. * Still learning the names of basic materials. * Some conserving of resources	C1: Look at this one! (sequin) What's it called? C2: It's like star.. C1: I'm going to stick it C2: I've found a tiny star, all blue and sharp. C1: Keep that one nicely. Hold it tight.
Talking Self Through * Revolved around skills and procedures. * Began to help planning	C1: Going to make a card like this. Fold it square, press it down like this. C1: I'm spreading, spreading glue like butter. Then I can shake on glitter.
Showing and evaluating * Openly showed and shared their work. * Some short comments about peers work. *.Some giving up or changing direction..	C1: Doggy card where are you? See my card. Nearly finished him. C2: Oh yes, a doggy card for Christmas. C3: Well look at my reindeer one then. C1: Can Hannah do it for me.'cos I don't like my card any more?
Identifying difficulties, Tackling obstacles,Sharing and cooperating. * Some difficulties with folding and joining skills. Beginning to draw more on group experience. * But most difficulties more likely to be identified and tackled alone. * Group begin to act together to correct mistakes.	C1: Can I have the glue? C2: Be careful with it. C3: Do you want me to show you how?. C1: No, I want to....I want to do mine! C3: OK,do it. C1: It doesn't come out. (glue from tube) C2: It's gotta come out. C3: Squeeze it hard. She needs more glue.

Table 22b Varying Aspects of Children's Strategies at the end of Y2 : Waterfields Infant School, Task: Thank You Cards

Strategies: end of Year 2	Example
Personalisation * Little direct personalisation. * Confident in immediately understanding the task. No need for concept building.	R: Our job is to make some thank you cards for the people who come to your class to help you. Who comes? C1: Mrs Helcame helps us with maths. C2: Mrs Shepherd hears people reading and I see her today.
Negotiation * Negotiated working together. * Took it for granted that they had a wide frame in which to work.	C1: Can we work together? That helps us. C1: You don't have to fold the card one way. C2: You can fold it back and then the flaps and there - a paper aeroplane Thank you card! C3: Now you can open it up in the middle. I can put the word 'open' on both wings of the aeroplane card.
Identifying needs * Used previous experience of materials to assess present needs. Now requested resources not on display and improvised if not available. * Human resources needs included requests for specific support from peers, and specific expertise from adults. * They saw the need to learn new techniques and practice for future sessions. * Extended consensus regarding future procedure. Extended conservation techniques.	C1: You need extra sharp scissors. C2: This is magic glue. It goes on purple and dries white. C3: This fur would do for a teddy bear. Got any ribbon for a bow? No? I'll use this felt. C1: I need two people to help me. C2: We will. Hold it quite hard to stick it. C3: Mrs Roden, can you cut this for me? C1: Can I use the glitter? C2: Best to use that last 'cos it will come off while you're doing the rest of the colouring. C1: Right, we know what we're doing. I can use it properly now. Practised last time. C2: Put the glue on and then get the glitter but sometimes it goes off the edge. So we shake it onto newspaper then all the glitter falls off except where the glue is. C3: Then you just fold the newspaper and funnel it back in the tube, see? Then it just all falls into the jar so you don't waste any.

Table 22b continued. Varying Aspects of Children's Strategies at end of Y2: Waterfields Infants. Task: Thank You Cards

Strategies: end of Year 2	Example
Focusing on materials * Focused in depth on tools, function and techniques,especially folding. * Some peer scaffolding remembering skills from past sessions.	C1: Fold it. C2: Yes but this way, corner to corner. C3: Like a book. C4: You get the corner and put it to the other C3: You should stand it this way. (on edge). C2: Or that way. C4: The corners always try to get apart don't they? C2: You have to press hard. C1: They spring apart. C3: You need to put the straight lines together.
Talking Self Through * Very little now, morediscussion.	
Showing and evaluating *Now discussed the criteria for designing and making throughout the session, but could still occasionally forget. *Evaluated product with peers and and modified accordingly.	C1: Someone will like that card. Very pretty. C2: It looks like a tree. C3: Looks more like an arrow to me. C2: I can make it look like a tree - just do this. (suggests modification) C4: Goodness you're trying to do it all in felt. That's a hard thing. C2: I just want to use the material. C3: I haven't really done any sticking apart from glitter. Maybe I should.
Identifying difficulties, Tackling obstacles, Sharing and cooperating. * Group more confident in use of tools and materials. Valued certain resources. * Cooperation valued. Children work together and give help, ideas and practical advice. * Tackling obstacles together now of an intellectual as well as physical nature. Pairs made joint decisions and planned together in situ.	C1: Look I'll use this ribbon for my leaves. C2: Look here's a brown for the tree trunk. C3: That's the one I used for my cover. R: I like the way you're measuring that. You've put it down and are just marking where it should be cut. C4: One day I think I'll go to the shop and buy some gold glitter - quite a lot. C1: I don't know how I'm going to get that thick glue on this really thin line. R: Well there's a problem. C2: Look I know how to make a thin line with that thick glue. C3: Perhaps get some other glue. C2: No you just go sh... with the edge of the spreader use the thin bit of the plastic. C1: It's quite tricky. C2: It depends. Look, use it like this.

7.2 Aspects of Complex Strategy Variation

From Reception to Year 2

These results describe complex strategy variation in the same children making cards in the Reception class and doing a very similar task in Year 2. While the tables chart all the strategies identified, this narrative pays particular attention to the variation in *Practice and Planning.* This is because, while other strategies could be fairly easily categorised into those that changed in nature, evolved or declined with age, *planning and practice* seemed not to fall into any of these categories. The interrelationship between Practice and Planning and its involvement with *play* seemed particularly complex. Moreover, the importance of planning, together with *evaluation*, in the D&T process seemed to single it out for attention.

In *Practice and Planning* different aspects appeared to change and evolve in an interdependent way. On entering school children did some rudimentary planning and practising through playing with tools and materials. At this stage play, Practice and Planning happened together and were almost indistinguishable. Later the elements became more distinct, gradually separating as children grew older. Young children talked about practice long before they talked about planning, but 'practice' for children seemed to be an early form of planning.

This is what it looked like in the classroom: When children entered school the boundaries between practice, play, and planning were very blurred. Reception groups tended to plan in a very short term way, through self directed speech, which was sometimes overheard and discussed briefly by peers. Here Reception children making Christmas cards plan aloud just before beginning to make:

C1: I'll colour this Christmas tree in shiny green.
C2: Shiny green?
C3: How am I going to stick this on? (cotton wool)
C2: I think I'm going to use some of this ribbon.....
C4: I'm doing a little face for the fairy. I'm going to do the eyes first, then the hair yellow.

Investigating the materials in self structured play was also a form of planning, as the children tried out materials they would use later when focusing directly on the task:

C1: I'm putting some decorations on my tree. Can you pass me some of them? (sequins)
R: What are they? Do you know?
C1: They look like flowers. Kind of decorations. Look, they shine. Different shapes as well... Put them in line... They make a pattern. You could put one colour, then the next... Some on the cotton wool. Will they stick on their

own? (holds cotton wool with sequin on upside down)
R: They are called ... sequins. (child plays with sequins for some time before using them on his card)

The same children in Year 1 making toys physically placed materials together as a form of planning and seemed to view play activity as practice, using the words practice and play in relation to the same activity. Here they play with the materials:

R : What are you doing?
C1: I'm just putting it together aren't I ... just to see whether it would work. Just having a go by just laying the materials together ... just to see how it would look ... I think that's a good idea at the moment.
R: Yes.
C1: I think I'll make it bigger..... Yes.
C2: How do you cut this? Can we have a little play first...I mean practice?

Similarly, the same children in Year 2 sometimes used *practice* and *planning* in the same interchangeable way, although now they were consciously aware of the need to plan. They did this at first in a concrete way, placing materials together before joining, and saving materials for later use, and then in a more detailed and abstract way, drawing or making lists on paper. Here two seven year old children discuss planning their Thank you cards before making. They do this both in a physical way, laying paper over the card and folding it to the right size, and in an abstract way, drawing diagrams on paper to indicate where materials will be placed:

C1: If you want to practise (plan) the drawing on another piece of paper before you do it, you can.
C2: I'm going to write it in pencil on a plain piece of paper to see what it looks like.
R: What are the girls doing?
C1: Planning it out.
C2: We put a piece of white paper over the top of the card and drawn round the outline so as to make sure the plan is the same size as the card.
C1: I've folded my white paper at the bottom so it's the right size.

Later in the session these girls realised the possibility of changing their plans or modifying them, so constantly evaluating their own strategies, and they obviously understood the transient nature of plans as opposed to the final product. They seemed to know that it was the process of planning rather than the plan itself that was useful:

C1: I'm not drawing it exactly. It's just my plan so I don't have to draw it absolutely with everything right.
C2: I'm going to do this part then cut some ribbon. I think I'd better glue it with

strong glue, white glue's better than this stuff from the tube.

C1: I'm going to change it slightly from the plan when I draw it on the card. You don't see the pattern and I want it bigger. Anyway, I'm going to write something down the bottom in the space.

C2: I'm not spending too long on my plans, 'cause it's just a plan.

C3: You'd have planned it all, girls, but you won't be able to do it in time. (boy)

By the end of Year 2 they saw the value of practising skills, and could plan ahead to prevent problems with glue, glitter and wasting materials. They were clear about their joining and conservation skills and able to articulate technique and pass it on to their peers:

C1: Can I use the glitter?

C2: Best to use that last because it will come off while you're doing the rest of the colouring.

C1: Right, we know what we're doing. I can use the glitter properly now. 'Cos I practised last time.

C2: Put the glue on and then get the glitter but sometimes it goes off the edge. So we shake it onto newspaper then all the glitter falls off except where the glue is.

C1: Then you just fold the newspaper and funnel it back in the tube, see? Then it just all falls into the jar so you don't waste any.

Reception strategies revolved around play and physical manipulation, while Year 2 children used practice and were conscious of the need to plan on paper. In this way the separate strategies of *practice* and *planning* emerged from *play,* play being used in a less obvious way as children moved through Key Stage 1. Something of the complex interrelationship between the strategies of *practice* and *planning* have been indicated here.

7.3 Supporting Evidence of Strategy Variation

Having taken a large leap over two years and eight months to look at certain strategies in the Reception class, and at end of Year 2, it was now necessary to go back to look at the intervening years. This needed to be done in order to support the findings of general strategy variation found in the first school. The following comparisons were made between groups of children in the second school doing similar tasks and using the same type of materials, tools and resources (Chapter 3, Tables 8b). At the end of Year 1, the groups at Waterfields Infants designed and made model toys as part of a history project related to the Victorians, and at the end of Year 2 they created puppets. The following tables compare aspects of their strategies during this time (Tables 23a, 23b, 24).

Table 23a Varying Aspects of Children's Strategies at the end of the Y1: Waterfields Infants. Task: Victorian Toys

Strategies at end of Y1	Example
Personalisation * Some personalisation, especially regarding the task.	C1: Victorian children had paper boats. C2: I'm gonna make a boat 'cos I got one at home. C3: I'm gonna make a dolls' house. OK? C 4: Could I make a fort?
* Understood the task but checked with researcher.	C1: What about a pirate ship? C2: Could you make something else? C5: Can I make an aeroplane? C4: They didn't have toy aeroplanes in Victorian times so he can't, can he? C1: Is that better for cutting the card? (offers snips) C2: This one is really hard(pair of scissors). C1: Well, we could find a better one.
Negotiation *Some negotiation around what allowed to make but still tentative about stepping outside the boundaries of the task.	
Identifying Needs * Chose resources according to fitness for purpose but only within the tools and materials provided.	
*Used experience to gather and use tools they would need and to store or save materials they planned to use later in session.	C3: My doll might need the legs to be pinned on or hard glue. C4: This will do for the pirate sail. (white cloth) C5: Wait ..this wood will be easier for the drawbridge. Save it for later.
Planning and Practice * Request to practise but some children likely to forget the task in favour of experiencing the tools and materials.	C1: I might use that for the eyes, stars for the eye? Yes, those sequins for the mouth, right. C2: What about the nose?
* Slightly longer term planning through discussion.	C1: Right, so stars for the eyes ... and a star for the nose. C2: Practise with a tiny glue stick so not too much. C1: First I'll glue the head on ... right.

Table 23a continued_ Varying Aspects of Children's Strategies at the end of the Y1: Waterfields Infants. Task: Victorian Toys

Strategies at end of Y1	Example
Focusing on Materials * Groups focus more selectively on tools. Discuss their use and function. * Check with researcher concerning use of some tools and materials.	C1: I need the pencil to mark where I'm sawing. C2: I want a hole through it. What could I use, Mrs Roden? C3: She could use a drill. It's OK, isn't it?
Talking Self Through * Some talking self through.	C1: I'm wiping the worst of the glue off. .. I'll make a thicker funnel now with this tube.
Showing and Evaluating Self evaluation leading to some limited modifications.	C1: Look how Timothy holds that bit of wood. C2: Look, look, Mrs Roden.....Timothy lift it up again. Smooth the edge. C3: Mrs Roden, this is going all wonky. Mrs Roden, I've decided I'm not making a big ship. I'm just making a little boat.
* Some peer evaluation in situ, making tentative suggestions on how improvements could be made. These not often done.	C1: Look what I've done, too much glue. C2: I think it's best just to dab it, Nicholas, and then you stick the star on. C3: Dab it very carefully with that paper towel, to get the glue off. C4: And I'll take the star off...while you try to ... like put glue on.
Identifying Difficulties, Tacking Obstacles, Sharing and Cooperating. * Physical help given and some suggestions made for ideas to improve. * Difficulties very apparent to group. Began to see the gulf between what they would like to make and their ability to make it. * Sometimes lack confidence in working with resources. Growing awareness of the value of general as well as special resources such as glitter.	C1: There we are ... just one tiny bit. I've got a tiny bit of glue this time... C1: I can't seem to do this drilling. C2: I just need the pencil to mark where I'm going to saw...Just a pencil will do.

Table 23b. Varying Aspects of Children's Strategies at the end oY2: Waterfields Infant School, Task: Puppets

Strategies: end of Year 2	Example
Personalisation * Little direct personalisation. * Confident in immediately understanding the task. No need for concept building.	C1: I'll make the puppet stage. C2: I'll make a puppet wife. C3: I'll make a dog puppet. C4: I'll make a friend for the dog. C5: I'm going to make a child puppet. C6: I know, furniture for their house!
Negotiation * Negotiated working together. * Took it for granted that they had a wide frame inwhich to work.	C1: A bone. The dog might want a bone. C2: I'm going to help him with the stage. C3: Can we work together?
Identifying needs * Used previous experience of materials to assess present needs. Now requested resources not on display and improvised if not available. .	C1: Glue. We need glue. C2: Elastic bands. C1: Bluetak. C3: Pritt stick. C4: Paper clips ....you know... C3: Those pins that open on the back so the arms can move.
* Human resources needs included requests for specific support from peers, and specific expertise from adults.	C1: Help me by holding this paper. C2: Which side? C3: It's all gone. Mrs Roden, I need another piece of wood. C4: How can you cut this round wood. How will it hold still? R: You need to use this mitre block with the hole to hold dowel. C4: Can I have a go first? A little practice with this small bit.
* They saw the need to learn new techniques and practise for future sessions. * Extended consensus regarding future procedure.	C1: Now we're getting good at this. We know how to make more puppets.

Table 23b continued. Varying Aspects of Children's Strategies at end of Y2: Waterfields Infants .Task: Puppets

Strategies: end of Year 2	Example
Focusing on materials * Focused in depth on tools, function and techniques, especially cutting. * Some peer scaffolding remembering skills from past sessions. **Talking Self Through** * Very little now. **Showing and evaluating** * Now discussed the criteria for designing and making throughout the session,but could still occasionally forget. * Evaluated product with peers and and modified accordingly. **Identifying difficulties, Tackling obstacles, Sharing and cooperating.** * Group more confident in use of tools and materials. * Cooperation valued. Some children asked to work in pairs. * Tackling obstacles together now of an intellectual as well as physical nature. Pairs made joint decisions and planned together in situ.	C1: How do you make a hole? (use the drill) C2: You're getting in a mess. Look, watch me...you just turn. C1: Right. Turn the handle like this? C2: OK, but keep it up straight. That's it. C1: Ah, he's going to be too big to put in the house. C2: You mean the puppet theatre. C1: It could be a very big house...I mean stage. C3: He could bend down. If you made the door big. C4: This one's a pig. C5: This doesn't look like a piggy at all. Give him a bigger nose. C4: Mmm...like this? (shows cotton reel) C5: That's better, Mr Piggy. C1: Now we have to make a head. C2: We have to screw the head on. C1: Hey, can you just hold that up there for a minute? C2: Like that? C1: Where did you get the sellotape? C2: It's masking tape. C1: If I use this, it might work. C2: Yes, on the little body. C1: Oh, one puppet leg's longer than the other. That makes it difficult to stand up. C2: That's the same size as that one. C1: I know, the legs are too floppy. Make it stiff. C2: Yes, stick it to the body a bit.

Table 24. Comparing Aspects of Children's Strategies during their second and third year in school: Waterfields Infant School

Strategies at end of Y1:	**Strategies at end of Y2.**
Personalisation * Some personalisation, especially regarding the task. * Understood the task but checked with researcher.	* Little direct personalisation. *Confident in immediately understanding the task. No need for concept building.
Negotiation * Some negotiation around what allowed to make but still tentative about stepping outside the boundaries of the task.	* Negotiated working together. * Took it for granted that they had a wide frame in which to work.
Identifying Needs * Chose resources according to fitness for purpose but only within the tools and materials provided. * Used experience to gather and use tools they would need and to store or save materials they planned to use later in session.	* Used previous experience of materials to assess present needs. Now requested resources not on display and improvised if not available. * Human resources needs included requests for specific support from peers, and specific expertise from adults.
Planning and Practice * Request to practise but some children likely to forget the task in favour of experiencing the tools and materials. * Slightly longer term planning through discussion.	* They saw the need to learn new techniques and practice for future sessions. * Extended consensus regarding future procedure.

Table 24.continued Comparing Aspects of Children's Strategies during their second and third year in school: Waterfields Infants

Strategies at end of Y1:	**Strategies at end of Y2.**
Focus on materials * Groups focus more selectively on tools. Discuss their use and function. * Check with researcher concerning use of some tools and materials.	* Focused in depth on tools, function and techniques, especially cutting. * Some peer scaffolding, remembering skills from past sessions.
Talking Self Through * Some talking self through.	* Very little now.
Showing and Evaluating * Self evaluation leading to some limited modifications. * Some peer evaluation in situ, making tentative suggestions on how improvements could be made. These not often done.	* Now discussed the criteria for designing and making throughout the session, but could still occasionally forget. *Evaluated product with peers and modified accordingly.
Identifying Difficulties, Tacking Obstacles, Sharing and Cooperating. * Physical help given and some suggestions made for ideas to improve. * Difficulties very apparent to group. Began to see the gulf between what they would like to make and their ability to make it. * Sometimes lack confidence in working with resources. Growing awareness of the value of general as well as special resources such as glitter.	* Group more confident in use of tools and materials. * Cooperation valued. Some children asked to work in pairs. * Tackling obstacles together now of an intellectual as well as physical nature. Pairs made joint decisions and planned together.

7.3.1 Aspects of Strategy Variation from Year 1 to Year 2

Personalisation

The same groups of children in the second school, Waterfields Infants, made Toys in Year 1 and Puppets in Year 2. It can be seen from the findings that over these two years certain variations in the strategies could be noted. In Year 1 *personalisation* was now quite limited compared to the Reception class, and this had declined almost entirely by the end of Year 2. The type of *personalisation* found in Year 1 seemed to link home and school. Children related activities they did in school to those they did at home and began to link these with learning in a general way. For example, when using hard materials one girl remarked that she 'had a workshop at home', and children often referred to their parents using similar tools to those in school, but they did not take this further or draw on these reflections to improve their skills. By Year 2 these reflections had ceased and children linked activities with experiences in school rather than at home. In this way *personalisation* strategies declined markedly during the key stage.

Negotiation

In Year 1 the groups had thought that they had discovered what was allowed in school and they were reluctant to break the rules by attempting to ask if they could work outside the task boundaries and design and make something different. Even if a child suggested this, peers were the first to uphold the rules and deny the possibility of extending the task to include children's special interests. They felt it necessary to negotiate with the teacher before extending task boundaries. However, sometimes children found it very difficult to think creatively about what they should make and they lacked the confidence to try. They began to see a gulf between what they would like to create and what their limited skills would allow. By the end of Year 2, however, the children took for granted their understanding of the task itself and their right to extend the frame of the task without *negotiation.* They now negotiated working together and this strategy had moved from task based in Year 1 to socially based in Year 2. In the following passage a child in Year 1 could not think of a Victorian toy that he could make, despite many suggestions. This is followed by confident Year 2 pupils who extended the task and moved on to negotiating working partners:

Year 1

R: You still can't think of anything to make?

C1: No. Power Rangers .. . I can't think of anything else.

We still have videos and television. But I don't watch them ..

I don't have anything to play with.. ... I've forgotten.

R: You've forgotten what you play with? Well what about some of the ideas we've just talked about?

C1: We don't play with soldiers either ...anyway I can't make them. I .. have got

a lego too.

C2: Ahh .. well, you can make a castle maybe. Is that a good idea?

C3: Yeah, they might have had toy soldiers' castles.

C1: I can't do it.

Year 2

C1: Can we work together?

C2: You need more than one person to make a puppet theatre.

C1: Yes. We can be partners and do the stage. I'm making some furniture for the puppets.

C3: You can do men and wife puppets together too. Can we do that?

Identifying Needs

The Year 1 children could now choose resources carefully at the beginning of the session. They had a growing idea of what they would need at the start. They used their limited experience to choose lolly sticks for the arms of a fairy doll, and put aside string for the drawbridge of a fort. They sometimes found that resources they had gathered were used by other's if left about, so they found means of storing them in empty boxes until they were needed. This was a kind of physical planning, which extended to written lists and planning on paper in Year 2, when strategies revolved around requesting particular resources such as felt pens often not on offer, and specific support from peers and adults to help with certain tricky problems.

Practice and Planning

Year 1 groups sometimes used practice strategies, especially when using hard materials, but often cut up wood regardless of purpose or got carried away by creating a play/practice situation. Year 2 groups were more determined to use strategies to acquire skills and would practise skills and techniques seriously at the beginning of the session, often requesting the use of glue guns, drills, hammers and nails or more advanced equipment. Year 2 children extended physical planning strategies of Year 1, and modelled their ideas by placing actual components together or using temporary fixings. At the same time they talked through this planning activity with peers. Here they talk about a pig puppet in progress:

C1: Look at my pig.

C2: He's a little baby pig. Oink, oink, oink.

C3: Why don't you give it some legs?

C1: I've got legs, one, two, three, four. (places them in position to stick on)

C2: And a swinging tail.

C4: Can I have a look at your pig?

C1: I can't even think of what to do for his tongue. I've put a crayoned one there just for now.

C4: Maybe you need to do it poking out.

C3: How about that? How about that? (pointing to red felt)

C1: Can you cut me a bit, please?

Focusing on Materials and Talking Self Through

By the end of Year 2 the focus was very much on gaining skills and techniques when using tools and hard materials. The children were interested in how the tools worked and what they were made of. They discussed them with each other and shared information. They used standard measures to mark and cut now, rather than holding wood together and cutting it for equal supports as in Reception, or matching and marking with a pencil, as in Year 1. At Year 2 they were aware of the importance of amount, strength and weight of glue, and used imaginative means of joining materials, while in Year 1 they were still learning about the amount needed and the best position of glue.

Showing and Evaluating

Year 1 children *showed and evaluated* their work spontaneously throughout the session, in a more concentrated way than in Reception, and seriously responded to each other's problems, beginning to make sensible suggestions or offer workable ideas. By the end of Year 2 the groups discussed the design criteria during the session and could engage in self evaluation and think about testing their product. Here the children making the puppet theatre evaluate the work so far and suggest testing the walls:

C1: I'm getting on. Look at this theatre.

R: These walls are very good.

C1: They should be stronger ..... they might fall down.

R: Well, they're standing up now.

C1: I need some heavy wind. (to test them)

C2: But you can put sellotape on the bottom.

In Year 2 peer evaluation often led to modification of a product both during and at the end of the session. Here the question arises of the puppet's size:

C1: Are you making a wife puppet?

C2: Yeah.

C3: No, it's too big.

C2: Too big?

C3: Yeah. Men are supposed to be taller. Aren't they meant to be taller than women?

C4: Yes. They normally are.

C3: The men are... the men are higher than girls when they're grown up.

C4: Hey, Mrs, you have a little husband here. (talks to puppet)

C2: OK. That can be the wife, and that can be the man. (changes puppets' gender)

Here, two Year 2 children have modified their work in response to the critical evaluation of other children.

Identifying Difficulties and Tackling Obstacles

Year 1 strategies were different from Year 2, in that they were often less socially focused and children were more likely to recognise problems that they could not tackle or to struggle alone with tools or materials, sometimes getting side tracked. By Year 2 children often preferred to work in pairs and were able to offer intellectual as well as physical support. They helped each other in measurement calculations when cutting materials, and with ideas about shape, size and rotation. They were beginning to have a notion of scale, and children making puppets were concerned that they should fit the theatre, although they did not realise they were too big until half way through making:

C1: Try her in the theatre.
C2: She might be too big.
C1: Too big, it's too big for the theatre.
C2: We're not putting her in.
C1: She's going for a walk on the stage in front.
C2: Or we could make her legs smaller. Look, her head still sticks out the roof.

Sharing and Cooperating

Sharing and cooperation was highlighted as the children sometimes began to request to work together making Toys at Year 1. These requests were extremely common by the end of Year 2 as children spontaneously collaborated in making puppets, a puppet theatre and even the story:

C1: Are you making the little, little boy puppet?
C2: No, that could be the son.
C3: No, we're making a man.
C2: Anyway this is a teeny puppet.
C4: I know. This could be the boy, and that could be the little boy and they live alone 'cos they don't have a...
C1: That's like a story. Once upon a time.....
C5: Once upon a time there lived a wife.
C3: And she had a husband.....a man.
C6: This is his knife.
C3: A stunt man! I saw one on a cartoon.
C1: There's a piggy too, and a dog called Smoky.

The information from the comparisons, in the second school, was collated in order to chart the variation in aspects of the strategies of those children over Key Stage 1 (Table 25).

Table 25 Aspects of Strategy Change over KS1 for Groups at Waterfields Infant School.

YR in Progress	End of Y1	End of Y2
Personalisation * Much direct personalisation. * Little confidence in task related ideas.	* Some personalisation especially regarding the task. * Understood the task but checked with researcher.	* Little direct personalisation. * Confident in immediately understanding the task. No need for concept building.
Negotiation *Limited negotiation. Accepted the task as given. * Negotiated whether they could take the product home.	* Some negotiation around what allowed to make but still tentative about stepping outside the boundaries of the task.	* Negotiated working together. * Took it for granted that they had a wide frame in which to work.
Identifying needs *Requested resources according to their favourite colour rather than because they were fit for the purpose. * Wanted to experience new or interesting materials on display regardless of the task. * Some watching and waiting for guidance.	* Chose resources according to fitness for purpose but only within the tools and materials provided. * Used experience to gather and use tools they would need and to store or save materials they planned to use later in session.	* Used previous experience of materials to assess present needs. Now requested resources not on display and improvised if not available. * Human resources needs included requests for specific support from peers, and specific expertise from adults.
Planning / Practice * Planned through self structured play and physical manipulation of materials. * Used the words practice and play as synonymous. * Very short term planning through talking to self.	* Request to practise but some children likely to forget the task in favour of experiencing the tools and materials. * Slightly longer term planning through discussion.	* They saw the need to learn new techniques and practice for future sessions. * Planned collaboratively. * Extended consensus regarding future procedure.

Table 25 continued Aspects of Strategy Change over KS1 for Groups at Waterfields Infant School.

YR in Progress	End of Y1	End of Y2
Focus on materials * Focused on all materials in turn through play. * Still learning the names of resources. Discussed their properties. * Began to conserve.	* Groups focus more selectively on tools. Discuss their use and function. * Check with researcher concerning use of some tools and materials.	* Focused in depth on tools, function and techniques, especially cutting tools. * Some peer scaffolding, remembering skills from past sessions.
Talking Self Through * Much in evidence.	*Some talking self through.	* Very little talking to self now.
Showing/evaluating * Showed and shared spontaneously. Some comments on peers' work. * Some giving up or changing direction when dissatisfied with own work. Early self evaluation.	Self evaluation leading to some limited modifications. * Some peer evaluation in situ making tentative suggestions on how improvements could be made. These not often done.	* Now discussed the criteria for designing and making throughout the session, but could still occasionally forget. * Evaluated product with peers and then more likely to modify accordingly.
Sharing and cooperating * Began to acknowledge own difficulties but peer comments often ignored. * Some difficulties with folding and joining skills but beginning to draw a little on group experience to tackle these. * Group began to act together to correct mistakes.	* Physical help given and some suggestions made for ideas to improve. * Difficulties very apparent to group. Began to see the gulf between what they would like to make and their ability to make it. * Sometimes lacked confidence in working with resources. Growing awareness of the value of general as well as special resources such as glitter.	* Group more confident in use of tools and materials. * Cooperation valued. Some children asked to work in pairs. * Tackling obstacles together now of an intellectual as well as physical nature. Pairs made joint decisions and planned together in situ.

7.4 Children's Changing Strategies?

These age related comparisons were compiled in response to the following questions:

* Do some strategies change in nature and emerge or decline with age?

* Do some strategies remain unchanged in nature but evolve to become more elaborate?

Do some strategies change but emerge with age?

The results from the second school showed that some strategies actually changed in nature with age. *Negotiation strategies* were either not used at all in the Reception class, or used in a very limited social way to negotiate whether products could be taken home. Groups used some negotiation in Year 1, but they were still tentative about extending the boundaries of the task itself. They checked with an adult what was 'allowed', both in the use of tools and materials and in re-posing the task in line with their own interests, while by the end of Year 2 negotiation emerged as task, skills and socially based. Year 2 groups took it for granted that they had a wide frame in which to work, could describe the boundaries of the task clearly to other groups, and negotiated working together. *Negotiation strategies* then, emerged only very gradually the Reception class, developed towards a task and material dependent focus in Year 1, and were socially oriented as groups moved through Year 2 (Table 25 continued).

Sharing and cooperating strategies also emerged with age. During the reception class children worked independently but alongside their peers. Children began to develop an awareness of the value of physical help in Year 1 when, as one child put it 'you need three hands', and then a more fuller appreciation of the value of working with a partner in Year 2. By the end of Key Stage 1 children asked to work together, could scaffold peers in terms of ideas, give useful advice, and also offer physical help. In Year 2, children were also much more aware of their own capabilities and knew when adult help was needed, as opposed to that of a friend (Table 25 continued).

Panic and persistence strategies also seemed to emerge with age becoming more sophisticated and socially based. They seemed to occur throughout the key stage, with one or two instances in all D&T sessions throughout the study. All groups seemed to use them to some degree towards the end of the lesson but they became much more sophisticated in older groups. They were provoked towards the end of the lesson by adult reminders of the need to hurry as time was running out. Perhaps it is debatable whether they could be called strategic, but they were successful coping behaviour, effective in generating rapid results when necessary. *Panic and persistence*, emerged radically as children grew older.

Do some strategies change but decline with age?

Strategies that actually declined with age were *personalisation* and *talking to self. Personalisation* appeared to be used extensively when children entered school, and helped them to relate D&T tasks, tools and materials, to similar personal experiences at home. By sharing this personalisation, through discussion, the groups were supported in concept building, gathering ideas, and making sense of the task. By the end of Year 1, groups were using past experience to reflect on similar tasks at school rather than at home. This aided present work, in both a practical and intellectual way, but much of the very personal aspect of this strategy had declined. By the end of Year 2 personalisation had all but disappeared and groups now seemed not to need it (Table 25).

Similarly *talking to self* was used extensively by groups in their first year at school. This revolved around skills and procedures, as children thought aloud about what they were doing or were about to do. In this way talking to self aided planning. During Year 1 children used some talking through, but this was sometimes aimed at other's as well as themselves, and was now more reflective, moving from present to future, then to past. Children talked themselves through what they were doing, what they should do next, and then reminded themselves what they had already accomplished. Conversely, groups of Year 2 children tended not to use talking to self. They discussed their work with friends but, noticeably, there were long periods of self imposed silent concentration as the children tackled the tasks. In this way this strategy appeared to decline or was perhaps gradually internalised over Key Stage 1.

Do some strategies remain unchanged in nature but evolve to become more elaborate?

Some strategies evolved with age, simply becoming more elaborate rather than changing qualitively, as children grew older. These evolving strategies seemed be be *identifying wants and needs, focusing on task or materials, identifying difficulties, and tackling obstacles,* and in a more complex way, *practice and planning* and *showing and evaluating.*

When *identifying needs* and *focusing on task or materials,* Reception class children who were new to school had limited experience of the tools and materials they would need to design and make in the classroom, and would sometimes watch and wait for adults to provide, but could gradually identify a growing list of basic resources such as card, pencils and glue. They used their experience of similar tasks at home, requesting their favourite colour when using card, regardless of fitness for purpose. They had little idea of choosing resources according to criteria inherent in the nature of the task, or of the condition or effectiveness of the equipment. However, they gradually began to reflect on previous experience and to extend their knowledge of tasks and materials so that by the end of the reception class there was an emerging group consensus outlining a simple order of procedure in designing and making. For example, when making cards, 'First

you fold it, then you draw on it, then you decorate it'.

These Reception children wanted to focus on *all* the materials provided, especially new or interesting resources that were attractive in terms of colour, sparkle, shine or softness, regardless of need. They wanted to explore in depth the properties of each material, investigating them thoroughly in self structured play, often taking time out of the task in hand to focus on this. They were aware of the need to conserve attractive materials, and began to consider the amount of resources used, and to collect unused material, tidy tools, and clear away after the session.

By the end of Year 1 groups could *identify an extended list of needs*, choose and gather their own resources, and were more proactive, relying less on watching and waiting. They were more likely to choose colour and materials considering fitness for purpose, but only within those resources displayed. They focused *more selectively* on tools and materials, discussing their use and function and checking with adults. They had firm ideas about appropriate tools for school and home, and about tools and gender (Table 25).

Oldest Year 1 groups saved resources they would need later in the session and conserved those they valued to share with friends in the group. They began to see peers as a human resource, so that by Year 2 their identified needs included specific requests for help from peers, and expertise from adults. They used imagination to request resources that were not provided, such as double sided sellotape, and they improvised and conserved materials for future sessions. Within the Year 2 groups an extended consensus regarding order of procedure reflected the complexity of the D&T process, and how the strategies of *identifying needs and focusing on materials* had become more elaborate, evolving with the children's age.

Similarly, the strategies of *identifying difficulties and tackling obstacles* evolved with age. Reception groups could identify difficulties but only occasionally act to correct mistakes, and then in a limited way. They could dispense support and sympathy, however, and sometimes give advice, although this was not always acted upon. Sometimes remedies made things worse, like washing glue off card with water. Giving up, or changing course, was used as an effective way out. At Year 1 the children were still struggling with manual skills but now had some experience of joining, cutting and measuring materials. They were still sometimes reluctant to accept advice but began to exchange physical help in tackling obstacles. By Year 2, children were more confident in their use of tools and materials, were more aware of where they had gone wrong, and had built valuable skills and strategies to tackle difficulties. Not least of these was sharing their problems with other's and pooling advice.

Complex Evolving Strategies

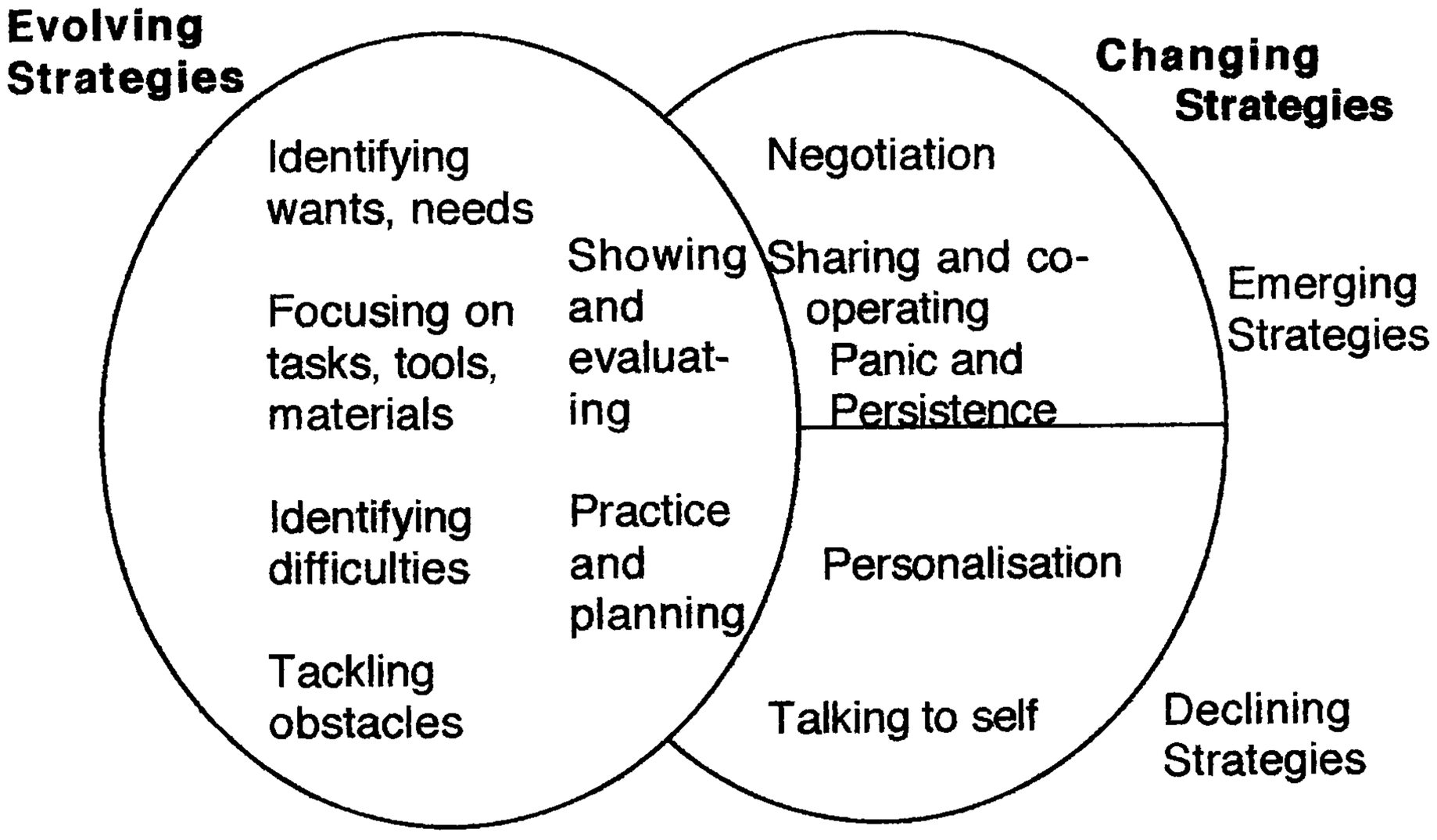
The nature of the evolution of *showing and evaluating* strategies was more complex as, like *sharing and cooperating*, they seemed be more socially based. Showing was used predominantly by Reception and Year 1 groups, when evaluation was restricted to short comments concerning personal likes and dislikes. Self evaluation was often used to loudly deprecate their own work and gain reassurance. At Year 1 evaluation still reflected personal preference and not product criteria, but by Year 2 there was less open showing, but more critical evaluation of work by peers, and some self-evaluation and awareness of their own learning by the children. This extended evaluation, now led to some modification of products, particularly by children whose work had been spontaneously discussed by their peers and suggestions made for improvements. There had been a substantial social evolution of this strategy which had an impact on subject specific skills over the key stage (Table 25 continued).

Practice and planning strategies seemed to evolve in an even more complex way. Here different aspects of the strategy evolved interdependently. The complexity of the process is difficult to describe, but it appeared from the findings that on entering school children did some rudimentary planning and practising through playing with tools and materials. Later these elements seemed to separate, gradually emerging from an amorphous whole into separate strategies as children grew older. When children entered school the boundaries between practice, play and planning were very blurred. Reception groups tended to plan in a very short term way, through self directed speech, which was sometimes overheard and discussed briefly by peers. Investigating the materials in self structured play was also a form of planning, as the children tried out materials they would use later when focusing directly on the task. Year 1 children seemed to view play activity as practice, and used the words *practice* and *play* in relation to the same activity. Similarly, children in Year 2 sometimes used the words *practice* and *planning* in an interchangeable way. They were now aware of the need to plan and did this in situ in a concrete way, placing materials together before joining, and saving materials for later use; and also in a more prospective and abstract way, drawing or making lists on paper. Both these means were used collaboratively. In this way the separate strategies of *practice* and *planning* evolved from *play,* play being used in a less obvious way as children moved through Key Stage 1.

7.5 Summary

It can be seen from the evidence presented that the strategies used by the children in the second school changed in a similar way to those used by children in the first. They changed or evolved, declined or emerged, as the children grew older and moved through Key Stage 1. It is noticeable that it was the personal and interpersonal strategies that tended to change radically, emerging or declining as children collaborated more with their peers, while subject specific strategies evolved gradually in a simple or complex way. Two of these subject specific strategies seemed to be particularly complex in the way they evolved and also seemed to be more socially based than the rest. This is shown in the final chart of this chapter (Table 26).

Table 26 Strategy Variation over Key Stage 1



Chapter 8
Discussion

Introduction

This thesis stemmed from the basic problem that in design and technology education little research has been done into the ways children tackle designing and making activities. It was hoped to collect a new body of evidence that would contribute to the knowledge and understanding of children's collaborative problem solving strategies, and add to the theory concerning problem solving processes in design and technology. The research aimed to describe children's strategies and to look at how they developed over Key Stage 1. The thesis began by asking the following questions:

* To what extent can we identify and classify the intuitive problem solving strategies that young children bring with them to design and technology tasks?

* Is it possible to specify the nature of these strategies and the relationship between them in a taxonomy ?

* Do these strategies change in relation to D&T tasks and resources?

* If children are followed longitudinally over a period of three years, can a development or change in strategies be seen?

* If so, what is the nature of that change over Key Stage 1, and can it be explained?

The first two questions concern the taxonomy so it seems sensible to look at these together and then to focus on the two questions concerning strategy change during Key Stage 1. To begin to answer the research questions it is useful to reflect upon how these questions were tackled at the beginning of the study and how the work progressed. The study began by asking whether it is possible to identify and describe children's problem solving strategies.

8.1 Is it Possible to Identify Children's Problem Solving Strategies?

The first research question asked whether it was possible to identify children's problem solving strategies during their designing and making. The answer to this question is a qualified yes. At a general level it was possible to identify and classify the intuitive problem solving strategies that young children bring with them to design and technology activities. It was possible to specify the nature of the problem solving strategies used by the groups of children. At first we needed to describe them at a level that was sufficiently general to be used in a range of situations but not detailed, specific or tied to the tasks and resources. This general description was the set of strategies that formed the original taxonomy. These were the following:

Personalisation
Identification of wants and needs
Negotiation and re-posing the task
Focusing on tasks, tools and materials
Practice and planning
Identifying difficulties
Talking self through problems
Tackling obstacles
Sharing and cooperating
Panic and persistence
Showing and evaluating

It was possible to identify these strategies through examining 36 transcripts of five to seven year olds, engaged in D&T activities. This was a set of strategies that all these children used, regardless of their age or school, the resources available or the task they attempted. We might compare this with the four attainment targets of the first D&T National Curriculum Order (NCC, 1990), or the programmes of study (DES,1995 ; DFEE, 1999). In the present study, it was clear that the taxonomy would need to be refined, but we found that it was possible to specify the strategies children used regardless of whether they were Reception, Year 1 or 2, and regardless of the tasks, tools, or materials used. We were aware that the strategies were being used differently at different times but at first we wanted to identify some common core of strategies and be confident that we could work to refine this. However, it was clear that unlike, research on the problem solving strategies of older pupils (Mayo,1993; McCormick,1996; Johnsey, 1997), this taxonomy did not list the strategies divided into separate designing and making activities, but reflected how designing and making are carried out by primary children in an integrated way throughout the D&T lesson, and are inextricably linked.

8.2 Is it Possible to Describe these Strategies in a Taxonomy?

We wished to know the nature of the strategies and the relationship between them so we began to ask about their function and the purpose they served. The D&T National Curriculum programmes of study (DES,1995) list of procedures for Key Stage 1, was broadly concerned with clarifying, developing and modelling ideas, selecting tools, materials, and techniques and evaluating finished products, but it is widely acknowledged (Bowen, 1996; Johnsey, 1997) that at no point were young children required explicitly to research problems or generate strategies of their own. Only recently, in the Review of the National Curriculum, Consultation Materials (DFEE,1999), was the notion introduced of children as 'autonomous and creative problem solvers' (p 122). This was supported by the new National Curriculum for England (DFEE,1999) which required children at Key Stage 1 to think imaginatively'. In the present study, from the first it was apparent that in D&T lessons children use their own strategies to solve problems. It was necessary to ask what sort of strategies young children use in order to solve the problems they encounter in classroom design and technology. Are these all design and technology specific strategies, or are there additional strategies that they might use?

When young children first come to school they need to begin to understand D&T tasks and to discover what is expected of them as designers and makers of products in the classroom. They will need to develop D&T capability by using their increasing knowledge of simple mechanisms, structures, products, and applications, to design and make quality products (DES,1995). So there is a great deal for young children to learn when they first tackle D&T. However, the National Curriculum Orders (DES, 1995) gave little indication of whether they are expected to work together or alone. 'Clarifying ideas through discussion' and 'communicating design ideas through drawing' are mentioned briefly in the Key Stage 1 programmes of study (ibid, p2), but it was not clear whether children should discuss and communicate with the teacher or each other. The recent Orders (DFEE,1999) specify that at Key Stage 2 children should 'work on their own and as part of a team' but do not mention this for younger children.

In reality, in the early years classroom children do not work alone but with their peers, so that learning in design and technology is not only to do with subject content but also to do with working with others. Because the natural way of learning in early years D&T lessons is not for children to work in isolation but in parallel or in groups, when they first enter school they will need not only to become familiar with new tasks, tools and resources, but also to learn to work alongside, and in collaboration with, peers and adults. Children need to devise strategies to cope with problems in a variety of contexts. Obviously, to do this they need to use strategies that are designed for different purposes. In this study, it appeared that children used strategies that served different functions, and that these were of two types.

This was where the first major distinction became apparent between two types of strategies within the taxonomy. As we looked more closely at each strategy, we began to see that the strategies seemed to address themselves to different purposes. Firstly, it seemed that there were those strategies that were subject specific, to do with tasks, tools and materials, processes and products. These strategies were used by children to think ahead about the D&T task, to choose the tools and materials that they might need, to investigate the properties of these materials, and to practise with the tools. These strategies were used in children's discussions about possible products and what function they might fulfil, and in planning verbally and on paper. These were D&T based problem solving strategies that were used by children to meet challenges during the activity. Finally, these strategies were used by children in evaluating and modifying both their performance and their end product. They reflected the creative challenge of problem solving discussed in the recent report'All Our Futures' (DFEE,1999). The function of this first type of strategy was to create more effective problem solving using the basic knowledge and skills of design and technology. Like the procedures listed in all National Curriculum Orders (NCC,1990; DES, 1995, DFEE,1999), these strategies concerned D&T as a subject area.

But there was a second type of strategy that was not necessarily about design and technology alone, but about communication and relationships in general during problem solving. These strategies were people oriented and had to do with how children organised themselves, or worked within groups, or negotiated with the teacher and others in order to solve problems. They were personal, in that there were some strategies that were oriented towards self scaffolding or making links to support and extend individual understanding; but they were also interpersonal, because some strategies were used to aid communication and collaboration, and to build productive relationships towards more effective problem solving.

The social context in which Technology takes place in primary schools has in the past been recognised by the Scottish Curriculum Council (The Scottish CCC,1996). Although in this study we identified the social strategies within D&T activities, these personal and interpersonal strategies were quite general and might be used in many other contexts both inside and outside school. Children use these strategies wherever they need to work together to solve problems in the classroom or playground or at home or in the community. However, it is possible that personal and interpersonal strategies are used more in design and technology lessons than any other because they rely so much on practical interaction and cooperation.

In summary, although a number of strategies were identified initially, as we began to examine each of the strategies in turn, looking closely at their functions we were able to arrive at a distinction between them. This further investigation made it clear that the strategies fell into two categories. They could be described as either D&T specific, or personal and interpersonal. Some strategies fell very obviously into one category or

the other and one or two strategies had aspects of both categories, although a dominance of one type. The following sections aim to discuss each of these categories in turn and to speculate on the function and development of the strategies during children's problem solving.

8.2.1 Subject Specific Strategies.

Identification of Wants and Needs was a strategy that was used predominantly at the beginning of the D&T lesson by younger children, but recurred throughout the activities with older children as lessons grew longer, and they were able to recognise new options and take fresh initiatives in response to unforeseen challenges. 'All Our Futures' (ibid) talks of the value of young creative thinkers not only as problem solvers but problem seekers as they lead us to new technological inventions and horizons. Richie's (1995) work with young children supports this. *Identification of Wants and Needs* served to help children to think ahead concerning materials, tools,or possible products. They used this strategy to select tools and materials they might use, or consider new ideas. Older children also identified the friends they wanted to work with or if they would rather work alone. But children also used this strategy initially to identify the overall demands of the task in terms of the knowledge, skills, techniques, and experience they might require to tackle it.

Focusing on Tasks, Tools and Materials. This strategy was used by children throughout D&T lessons and served to direct their attention to the three major components of all design and technology activities that is, the task, the tools and the materials. Firstly, the children focused on the task itself and the function of the task related to its possible authenticity, or why they they would need to design and make the end product. Like pupils of all ages (Craft Council Research Project,1998), they wanted to take their products home and where possible use them. This strategy helped young children to decide, for example, to whom they might send their greeting card and what type of card that person would like to receive. Secondly, this strategy was also used to focus on the tools, and whether they were new or known to the children and if they needed to practise with them. Thirdly, children used this strategy to direct their attention to choice of materials and how these might be used. *Focusing on Tasks,Tools and Materials,* was a strategy that enabled children to concentrate on any of these components so as to clarify what needed to be done to solve problems.

Practice and Planning seemed to be rehearsal strategies that children used to prepare both physically and intellectually for further action. Again, they were used by younger children in a very limited way at the very beginning of the lesson, but were extended and used more frequently by older children. When practising the use of tools, children recognised the need to gain experience of the tools and to train themselves in techniques for their use, so that they had at least some proficiency before attempting to create a product. However, sometimes children became so preoccupied with, for example, sawing wood, or manipulating materials that they forgot the original task.

Here practice became a goal in itself because children wanted to become good at sawing wood. Practising is important preparation, and developing practising skills in making, and investigating tools and materials, were seen as key aspects of the D&T programmes of study when recently reviewing the primary D&T curriculum (DFEE, 1999). In the present study, the children appeared to see a strong interrelationship between practice and planning strategies, and older children seemed to regard planning as a form of practice. This supports Outterside's (1994) research that when planning, young children first imagine new possibilities through role play and action, then represent these ideas through the media of words and images, and finally through symbols and drawing. In the present study, even the youngest children saw the need to think ahead, conjure an image in their mind of what they might make, and verbally schedule a simple order of work. The oldest children were able to estimate on paper the resources they might need, predict the processes they might use, and draw what the product might look like.

Identifying Difficulties and *Tackling Obstacles* are basic to problem solving, but strangely were not explicitly represented in the National Curriculum D&T programmes of study (DES, 1995). Perhaps they are implicit in the procedures of *suggesting how to proceed or identifying strengths and weakness*, (ibid), but within these Orders, and sadly the most recent programmes of study (DFEE,1999), the terminology is bland and it conveys little sense of the challenge and intellectual struggle required. This struggle was so apparent when observing children in the present study encountering difficulties, exploring possibilities, venturing novel ideas, disputing and arguing, and exerting all their efforts to devise and use their strategies. The function of these strategies was to cope with the continual snags and complications of problem solving as they arose throughout the D&T activity. The children seemed to cope by unconsciously separating the problem into two aspects, first of specifying the difficulty and the need to overcome it, and then by thinking of ways of attacking the work. Some problems can be solved routinely and logically, but D&T requires imagination and innovation (NACCC,1999). Here children seemed to intuitively use their strategies to analyse hurdles, decide what type of response was needed, and apply more precision to their problem solving.

Showing and Evaluating. These strategies served to support children in sharing the work as it progressed, and appraising each other's performance and product. Younger children seemed to display their work to peers and adults as the lesson proceeded so as to check that they were on the right lines and gain confidence. These *Showing* strategies demonstrate that at an early age children can recognise the possibility of improving their work and believe in the possibility of change (Dweck,1988). Change is an intrinsic part of design and technology which should encourage control and 'mastery oriented' attitudes in children (Dweck,ibid). Sometimes children deprecated their work in order to gain reassurance, underlining the importance of self-esteem. Using *Showing* in order to please the teacher also plays a large part here, but Sylva (1993) has found that

this kind of extrinsic motivation can sometimes encourage learned helplessness.

During evaluation, older children did less actual 'offering up' of work in progress to their peers for assessment, but were more proactive in seeking to evaluate the work of others. They used this strategy extensively later in the lesson and at the end. This provided experience in making judgments about the work of peers, and was useful for gaining feedback about the quality of their own work so that modifications might be made. In this way children were able to reflect on what they and others had done, to compare, rate and assess it, and to give or take advice. Peer recommendations, and sometimes criticism, often served to improve quality. For example, Reception children presented their invitations to each other for appreciation, and Year 2 children's criticism of each other's Rain Forest Shelters, prompted radical improvements. These children explored what was appropriate in terms of presentation of the product and what users might require. Recent research by the Nuffield Foundation (1997) suggests that the role of users in product realisation needs to be more widely recognised in the classroom.

The strategies described above would appear to be associated specifically with the design and technology aspect of the activity and to do with it as a discrete subject. It seems possible that in any D&T classroom children will be engaged in purposeful, problem solving activities that we could call subject specific strategies. Although, like other researchers (Kimbell et al,1991; McCormick, 1996; Johnsey,1997), we have moved away from the simplistic view that there are a single set of transferable procedures for designing and making in all situations, nevertheless these strategies are not random but seem to follow a pattern concerning extent and frequency of use at certain ages. Within an integrated process of designing and making, certain D&T based strategies, such as *Identifying Wants and Needs*, are invariably used at the beginning of the lesson, and others, such as *Evaluating* strategies are used towards the end. Strategies such as *Identifying Wants and Needs* are closely tied to the goals of problem solving and seem a natural precursor to *Focusing on the Task, Tools and Materials* , which appears to lead to the need to use *Practice* strategies. When faced with a D&T task children first focus on the task to try to interpret what it means and find out what they know about it, then they identify what they need regarding resources, and support, and then they focus on the tools and materials. Perhaps they ask to practise with unfamiliar tools, encounter difficulties, try to tackle them, and so on. Again the context of the task dictates how the strategies are used. It seems that children structure and tailor their strategies to fit the problems they encounter at certain points in the activity, and change and modify according to their experience of tasks, tools and materials. So the strategies vary in terms of the way they are used by children depending on the context.

However, there is a danger that young children may be perceived as consciously logical in structuring the problem solving strategies they use in a rational sequence. This may seem unlikely as it would entail awareness of their own procedural knowledge. *Procedural knowledge,* in D&T, is understanding when to apply skills or techniques, such as cutting and joining, as part of a strategy for tackling a D&T problem. McCormick (1999) sees these as lower order skills, not to be confused with *strategic procedural knowledge* which, at a higher level, determines the order of procedures and includes the processes of design and problem solving, such as modelling ideas. Strategic knowledge is knowing when and why to use complete problem solving strategies, and the skills within them, and to be aware of this in a metacognitive way: children not only need to develop process skills, and techniques, they need to understand how and when to apply them, and need to be aware of and articulate this knowledge. It seems from the study that by the end of Key Stage 1, children can be aware of and discuss their own skills and techniques, so they have some procedural knowledge, but strategic knowledge is much more sophisticated.

Procedural knowledge develops slowly in young children who sometimes just want to have fun and enjoy designing and making, and may use their strategies in inappropriate or unproductive ways. But they do express a particular 'interest' (Kress,1997) or intuitive intent by their strategies, even though it is not that of the adult. For instance, they may not look ahead to the needs of the user or the quality of the end product. McCormick (1997) has written of product 'tyranny' and found in case studies in secondary classrooms, that product outcomes tend to undermine some problem solving processes that teachers should be concerned to foster in pupils. However, Kimbell (1996) has found that young children in particular are competent in empathising with users and focusing on products, and that encouraging them to specify criteria at the start of the activity is important, as this gives them 'ownership' of the task. If children do not use a vital strategy, at the beginning of the D&T activity, such as focusing on the product or task or planning, we might question whether it is the role of the teacher to bring them back to discuss it, or try to make their following strategies more schematic and focused. There are various opinions on this. Barlex (1995) maintains that teachers often need to help children to focus on the task and make explicit the criteria for design and making so that evaluation throughout the activity may be more focused, but others see this as stunting creativity (Black,1998). In the past there has certainly been a danger that given a possible linear or cyclical set of D&T strategies by NCC, teachers have 'strait-jacketed' children into adopting these in a prearranged sequence. This is why it is important that this study has demonstrated that, especially as children get older, strategies can run in parallel as well as in sequence, and that certain strategies can be used spasmodically throughout the whole of the design and technology activity.

We have seen how the use of this type of D&T related strategy develops as children grow older and gain more experience, understanding, skill and confidence in the subject. Although some of these strategies are sometimes used in other areas of the curriculum, such as mathematics, it appears that many, especially those to do with tools and materials, are specific to design and technology education. So we can be confident that during D&T lessons children use a group of strategies that are subject specific and to do with design and technology. These are the following:

Identifying wants and needs
Focusing on tasks, tools and materials
Practice and planning
Identifying difficulties
Tackling obstacles
Showing and evaluating

Each of these strategies has now been discussed specifically, but what are the general characteristics of these D&T specific strategies as a group? It appears as though certain features of the context, which can be called 'the task in the classroom setting', are determining factors in which strategy is used. These features could be the purpose of the task, to produce a certain product, or they could be the manipulation of tools or use of materials. Children focus on these spasmodically, one at a time, rather than constantly holding an holistic view of the context because certain goals or motivating factors focus children's attention on the process and product of an activity. These determining factors can vary according to whether the children perceive the tools to be the most interesting feature of the task and wish to practise with them, or see the materials as new and exciting, such as glitter or sequins, and want to explore their use. Maybe they are interested in the end product, such as a greeting card, and want to take it home. Here then, are a set of strategies that are context determined, but the context, or D&T task within the setting, incorporates the different facets of the product or process that are important in deciding which strategies children use. It is possible that this has to do with how much knowledge and experience of design and technology children bring with them, for example, whether they have used certain tools before, or if the materials are well known but constantly, throughout the D&T activity, one or other feature of the context will shape the way children use their strategies.

However, some of these subject specific strategies used in design and technology, such as *Showing and Evaluating* for example, have strong social or interpersonal elements. These strategies are necessarily used in collaboration with others and serve not only to improve an individual child's end product, but to support others engaged in similar tasks and compare expertise. But there are certain strategies that have been identified in the study which seem to serve a personal or interpersonal function. We will now look at this set of strategies.

8.2.2 Personal and Interpersonal Strategies

We will now turn to children's use of personal and interpersonal strategies. We have discussed strategies that are subject specific to D&T, but there are other strategies that would appear to serve a personal and interpersonal function. These are *Personalisation, Negotiation, Panic and Persistence,Talking to Self and Sharing and Cooperating* and they seem to be collaboratively determined.

Personalisation strategies seem to serve to help individuals make links with more familiar or intimate experiences in order to make sense of the task or problem. Doise and Mugny's (1984) 'socio-cognitive conflict' view of collaborative learning sees social interaction itself giving rise to the formation of new cognitive structures within the individual. The work of Perret-Clemont and Doise and Mugny (1975) points to the socio-cultural nature of that understanding and provides a view of the child as an apprentice to his or her own culture, inducted into learning by social support that creates a bridge from the familiar to the unfamiliar, and from the known to the unknown. *Personalisation* seems to be a form of 'self-scaffolding', especially for younger children as they attempt to categorise and classify objects, and identify the aspects of the D&T problem that are recognisable to them or that they can relate to. This strategy appears to help children to bridge the gap between school and everyday knowledge. The nature of *Personalisation* appears to be essentially private and subjective, but sometimes children attempt to make links with past personal experiences by discussing these with peers and teachers. For example children may check that the analogy they have made between school junior hacksaws and saws used by their parents at home is viable and therefore useful.

Negotiation strategies are also part of this group of personal and interpersonal strategies. The negotiating powers of older primary children have been well documented (Pollard,1985,1994), where teacher and pupils each have their own agenda and negotiate a 'working consensus'. In the present study we see the origins of children's negotiation strategies in the classroom. They are used in both a personal and an interpersonal way. Children are often personally motivated; for instance when they want to design and make a product of personal interest which falls outside the scope of the teacher directed task, they will argue to relax the task frame in order to accommodate their own wishes. This also happens when individuals seek to be allowed to use a particular tool or material that may be in high demand, or simply unsafe. These wants and needs stem from personal taste but also from imagination and original and inventive ideas. This inspiration and need for control is the basis of all good design and technology and should be encouraged by teachers.

The interaction of children during negotiation strategies makes these both personal and interpersonal. Corsaro and Rizzo (1990) analyse five-year-olds' negotiation of friendship groups and skill development as they argue in the Italian classroom. Similarly, children in the present study negotiated working partners. They also bartered with materials, exchanging valuable pieces and saving some for friends. Negotiation strategies

appeared to be used for whole group benefit when children wanted to promote working with partners. Here a whole group of children decided to use their collective bargaining power to put pressure on the teacher to change her plans for classroom management in favour of their preferred way of working. Individuals within the group showed definite preferences, and used body language to indicate who they wished to work with or if they wanted to work alone, but the initiative and bid for control seemed to come from the group as a whole. They demonstrated consensus concerning their 'practical theory' (Kress,1997) that when designing and making, often two heads and two pairs of hands are better than one. However, sometimes children haggled over resources, and could not agree to share the glue guns, for example. A conflict of ideas can easily become emotional conflict or 'personalised conflict' (Pondy,1972), especially in open-ended problem solving, and children may need to negotiate ways forward, or a clearer specification of the task. We suggest that this negotiation will be influenced by the unconscious allocation of power and control within the group.

The strategy of *Talking self through problems* appears necessarily personal because children talk to themselves as they work through a particularly tricky problem, or technique, commenting on what they have done or telling themselves what to do next. This strategy seems to have little to do with other people but it is very like children using themselves as another person, or scaffolding themselves. Doise (1990) reflects on previous investigations which showed that developmentally more advanced responses in children appeared in collective situations *before* individuals were capable of them. It has been illustrated how *Talking to self* is used by children to scaffold themselves by thinking aloud, however, for a short time it is shared. Interestingly, there seems to be a time, just before children begin to internalise these thoughts and stop using self directed speech, when this talking through a problem aloud is directed much more to those working alongside, or the group in general. In this way it can, for a short time, become interpersonal as well as personal before it seems to disappear altogether. Following Vygotsky (1978) it is in fact internalised as inner speech. In this way, although talking to self appears to be a personal strategy it may have interpersonal undertones.

Although *Persistence* strategies would appear essentially personal, they often need the support of others. These strategies are most often needed towards the end of the D&T lesson when children's energy is low and they realise that time is limited. Then they can either persist alone or engage the help of others. Sometimes they take the former option and struggle on independently to finish their work; at other times they use various strategies to enlist the help of either the teacher, their peers, or both. Persistence is a useful strategy in D&T, but dispositions, attitudes and emotions also play a great part. A recent study of the problem solving strategies of professional designers and makers (Craft Council, 1998) emphasised the need to cope with taking risks, especially on large scale projects, and spoke of enhanced self-esteem and self knowledge when problems were overcome. Children need to succeed to build self confidence. Emotional aspects of

learning in D&T are important for children and self-esteem is at risk because their work is not hidden from their peers in an exercise book, but on view for the opinion of others in the classroom.

Possible strategies that help children to seek help were those to do with *Pretend Panic* and role play. Corsaro and Rizzo (1990) study of five-year-olds found that boys were more likely to set up role play conflict situations during school tasks, while girls' help-seeking role play grew from a concern to support and agree. In the present study, *Pretend Panic* strategies appear to be both supportive and argumentative, and both personal and interpersonal. They are used by individual children to release personal tension when things go wrong or mistakes are made. But they are also used in an interpersonal way as a cry for help when disaster strikes, for instance, if a structure is collapsing or time is running out. Because these strategies, based on the use of high drama, demand the attention of friends, the teacher, and often the whole class, individuals manage to propel everyone into action.

Sharing and Cooperating strategies appeared basically social strategies, but may also have a personal element. They are 'help-seeking' as well as 'help-giving' strategies, used when children seek specific personal support. This often concerns the use of appropriate resources for specific purposes. Doise and Mugny (1981) maintain that most children working together in small groups experience more stimulation, construct more effective argument skills, devise more effective coping strategies, and subsequently perform better, than children working individually. Cross (1998) points to the advantages and disadvantages of children working individually, in pairs and in groups. In the present study children drew on each other's experience as to the best tool for the job or the most effective material.

Help giving has an interpersonal but also a personal purpose. Bold (1999) warns that expecting children to work collaboratively in D&T may result in a high level of discord. Friends often give advice without being asked for it and this is not always welcome. Motives are not always altruistic because children use this strategy as an excuse to exhibit their own knowledge and skills in front of their peers. Indeed, Doise and Mugny (1985) have argued that the cognitive progress of a child is enhanced where the social-cognitive conflict is intensified. Light and Perret-Clemont's (1989) idea of social marking is based on research that noted the positive effect of problem solving tasks within the context of competitive games. They suggest that perhaps it is the challenge of both intellectual and emotional conflict that results in developing new strategies and increases performance and enhances cognition. Edwards and Mercer (1987) talk of collaboration between children to create 'common knowledge', as the understanding created and shared by children through their interactions. They suggest that through discussing, negotiating and pooling experience, a new level of understanding is achieved, and that conflict of ideas may not be necessary. It seems that in the present study this was very much the case.

Personal and interpersonal strategies seem to be concerned with issues of working with one another. Although some of these strategies may appear personal rather than interpersonal, occasionally social interaction plays a part and they would appear to be used in many social and learning situations, both in and out of school. It is suggested that they are not dependent on D&T tasks, tools, or materials and, although essentially these are not context specific strategies, that design and technology activities evoke or elicit personal and interpersonal strategies, such as sharing and cooperating, and also enhance them. In the primary classroom children must inevitably share tools and materials in order to engage in D&T tasks. This, together with the constraints of problem solving itself, necessitates interaction. The present study has shown, and there is now supporting evidence (Burgess,1998), that peer collaboration during problem solving is important because children learn from helping as well as by being helped. The design and technology context enables children, sometimes for the first time, to feel the self-esteem and empowerment of helping others both in a practical and intellectual way.

When discussing personal and interpersonal strategies the work of Doise and Mugny and Perret-Clemont (ibid) referred to in the theoretical frame of this study has been helpful. The recent work of Galton et al (1992,1999) has also informed this study. However, in the field of D&T there is little work in this area that tells us about whether it is the task, the tools, or other aspects that relate to collaboration. In a recently published international journal, Hennessy and Murphy (1998) stated that 'despite the rhetoric of the curriculum, the use of collaboration as a learning mechanism is almost ignored in practice in D&T and has not previously been the subject of research'. So although in the theoretical area of social psychology, we are very well informed and it can be shown that collaborative strategies exist at all ages, in D&T we are less well informed because the research in design and technology is much less developed.

In relating children's personal and interpersonal strategies to key ideas of Doise, Mugny and Perret-Clemont (1979-1990), it can be seen that the study demonstrates similar findings to the body of social psychology literature. Importantly, it has found that when children are engaged in D&T they use strategies that help them in managing people and managing self. Young children are increasingly aware that peers and other people are useful and influential. They are also mindful of the need to be aware of the classroom culture and what is 'allowed' by the teacher, and to negotiate problem solving within those perimeters. Personal and interpersonal strategies are crucial and important for problem solving, as are subject specific strategies. Through the present longitudinal study it has been possible to see their evolution. Longitudinal studies are rare, but in this case taking the time to engage in longitudinal research has enabled us, not only to trace strategy change over time, but to suggest the nature and quality of that change. In the following sections, we will discuss how children's collaborative problem solving strategies change as they grow older.

8.3 Strategy Change over Key Stage 1

We have two groups of strategies: those that are personally and interpersonally determined, and those that are design and technology determined. We can now ask the second set of research questions: Do these strategies change in relation to children's age and experience, and if so what is the nature of this change over Key Stage 1? Basically, we need to ask ourselves, whether these strategies are used similarly or differently at different ages. Can we see the evolution in the way children use strategies from five to seven years old? If so, what is the sort of change they go through? But we also need to ask, what factors are involved in the way they change, because it will be important to know how we can support and enhance, or maybe counter this change. Let us look first at the group of strategies that we have called personal and interpersonal. What kind of change takes place here?

8.3.1 Qualitative Change

Looking first at the personal and interpersonal strategies, clearly they are very different when children first begin school from when they are seven. We hypothesise that these strategies are dependent on the whole of the social context, that is on what children are learning in many other situations. It has been suggested that D&T is a special context in that it enhances these strategies. However, they exist not only in design and technology activities but across subject boundaries and in other learning situations. These situations are found in school, at home and in the community, and these strategies develop within everyday life as children communicate with others and become social beings.

However, strategies change differently. The strategies of *Talking to Self* and *Personalisation* were used less by children as they moved through Reception and Year 1 so by the time they had reached the end of Year 2 these strategies were hardly used at all. They had declined markedly and then disappeared during the first years of school. However, *Negotiation* and *Sharing and Cooperating* strategies were used more extensively by children as they grew older. We can now speculate on the reasons for this. When considering the decline of *Personalisation* strategies, at the age of five children are still rather egocentric and focus on themselves. They tend to work alone, although always alongside and in relation to each other, and so to make sense of a problem or situation they need to relate it to their own personal experience. When these young children first come to school, in order to feel secure and confident about a situation, they need to make links for themselves with similar past experience, and feel that they are on familiar ground. As they grow older, learn more and gain confidence, although they still need to do this to the same extent, they may find that making these links overtly is seen as inappropriate by teachers, and they may internalise this process. Work by Rismark (1996) shows that pupils are frequently marginalised and their work undervalued if they use frames of reference from personal experience outside school. Filer (1995) found that

young children learning handwriting skills in primary schools were constrained by teachers to develop these in formal contexts so that their personal experiences were 'blocked out'. Perhaps as children grow older and become accustomed to the school culture they learn to make less home oriented links and more school oriented associations, but *Personalisation* appears a very useful strategy and might be encouraged by teachers as an effective form of self scaffolding.

Similarly, *Talking to self* as a problem solving strategy is used extensively by groups in their first year at school. This revolves around skills and procedures, as children think aloud about what they are doing, or are about to do. In this way talking to self aids planning. They talk themselves through what they are doing, what they should do next, and then remind themselves what they have already accomplished. It is suggested that this reflection comes last, as very young children find it more difficult to reflect and evaluate than to think about the present. For a time, as they get older, children may aim this self-directed speech at others as well as themselves. Older Key Stage 1 children tend not to use talking to self. They discuss their work with friends but, noticeably, there are long periods of internal talk (Vygotsky, ibid) or silent concentration as the children tackle the task. Perhaps as they move through the key stage children notice that talking to oneself is not socially acceptable, and become circumspect about how and when they use it and begin to talk to themselves inside their heads.

So, like *Personalisation, Talking to Self* in D&T is dependent on the whole of the social and cultural context, and on what children learn to be socially acceptable in many collaborative situations. In this way the strategy of *Talking to Self* appears to decline, or is gradually internalised, over Key Stage 1. During these very early years of school children use, to an extent, both *Personalisation* strategies and *Talking to Self* because, as they tend not to work together, they need to guide themselves through problems. As we have said, *Personalisation* and *Talking to Self* are declining strategies as these are internalised or made redundant with age. We surmise that this is because overt self scaffolding is now internalised thought, and peer and adult scaffolding are now also available through children's increased powers of cooperation.

Peer scaffolding takes over as children move through Key Stage 1 and use *Sharing and cooperating* strategies much more. The youngest children work independently but alongside their peers, but older children see the value of working with a partner and often ask to work together. Physical cooperation seems to come before intellectual cooperation because at first they just seek and offer physical help, but later they can scaffold peers in terms of ideas, and give useful advice and critical judgment. They are also much more aware of their own capabilities and know when adult help is needed, as opposed to that of a friend.

As they become more cooperative and communicative it follows that children also increase their bargaining powers, not just about what resources they use but about who they work with. Therefore, *Negotiation* strategies are not only extended but children use

them in a different way. At first they want to discuss the task itself to test their powers of persuasion and have some control over what they make. They want to make their product more personal or to relate it to home or a special interest. Then they want more control over the choice of materials, tools, and working space and, as they become more social 'top infants', they care more about working partners and ask to work with a friend or prefer to work alone. They now have strong social preferences. Younger children are still discovering the social boundaries that exist in school, so seem bound by what is 'allowed' in the classroom culture. Therefore, the scope of their *Negotiation* strategies with the teacher or adult is limited. Older children become more confident socially and are bolder, and while they acknowledge what is permissible in school, they now attempt to follow their own interests, wants and needs, and exert some control over the task frame. The oldest groups are familiar with the social and pedagogic boundaries in school and can act to take responsibility for tasks, tool safety, and cooperative working arrangements. They often completely revise or re-pose the task posed by the teacher, in order to design and make a more exciting product, or impose their will by introducing systems that pair the group into working partners, when the teacher had originally planned for individual work.

Clear and challenging goals or tasks are an essential element of learning (Sadler,1998; Dwyer,1998). Blumenfeld (1992) sees task setting as a central feature of learning. He calls for more research to produce detailed descriptions of task setting in the classroom emphasising children's voices and teachers' craft in negotiating criteria and constraints. This also implies the need for shared understanding of criteria for quality within the learning field, relating to both the process and the product in D&T. Sadler (1998) argues that one reason that standard design specifications need to be clear for all is that learners need to be able to make evaluative judgments independent of the performance of others. But small scale D&T research by Raynish (1998) indicates that when six and seven-year-olds are encouraged to set their own task criteria, they automatically relate to this personal criteria when evaluating their work.

As children collaborate more they learn to use the drama of social interaction to introduce strategies such as *Pretend panic* into the group. This role play is based on a real need for support, usually physical help, but is accentuated by children to attract attention and stimulate everyone into action. This strategy is used particularly towards the end of the lesson, together with *Persistence* strategies, which encourage determination, stamina and will power to complete the final product. These are finishing strategies to do with personal and interpersonal attitudes and values.

To summarise, it has been shown that many of the personal and interpersonal strategies that children devise and use in general social situations, are used and extended in design and technology activities. Children collaboratively construct these procedures for dealing with problems and use them again in other learning and social contexts. These personal and interpersonal strategies change qualitatively as children grow older, but beyond this, each strategy changes in a different way because some

decline or seem to disappear while others are used more extensively. We speculate that this is due to children's general social development and their increased ability to communicate and develop social confidence, attitudes and values. Consequently, in the D&T classroom, a seven-year-old's personal and interpersonal strategies look very different from those of a five-year-old.

The theoretical frame may inform the study concerning this qualitative change but clearly, there is a great deal of work, which the present study reinforces, concerning the development of social strategies which are then used in a subject specific context. Piaget and Vygotsky had somewhat different approaches to understanding this. Piaget (1969), as a constructivist, saw young children as constructing their own knowledge through logical thinking tools during practical activities. Both Piaget and Vygotsky believed in stage laws, but Piaget firmly believed in a series of paradigm shifts or qualitative changes in intellectual systems with age. Whereas, for Vygotsky (1978), intellectual development seemed to be a more gradual process, each phase representing new psychological systems which may completely replace the old, so that there is an explanatory emergence as new skills, new forms of thinking, and new attitudes towards the world develop (Van der Veer, 1995).

8.3.2 Cumulative Change

We must now look at the subject specific strategies, that is those that are directly design and technology focused. Do these strategies change in any substantial way, and if so what influences them, and what is the nature of that change over Key Stage 1? Do they change in the same or a different way from personal and interpersonal strategies? In fact, these strategies seem to change in a different way. We will look at each of these strategies in turn and discuss how this change might happen.

Whether children are five or seven years old, when they use the strategy of *Identifying wants and needs,* they are trying to find out what they would like or will require to do the task, but this necessarily depends upon what they know at the time. All children throughout the key stage use this strategy to decide what resources they require to carry out the task, so that essentially this strategy remains unchanged in nature, and whatever their age, children will still try to select the tools, materials, and working partners that will be most effective in designing and making the product. So, the core purpose of this strategy is the same, whenever it is used, and at whatever age, but the way it is used will depend on the increased experience, knowledge, and expertise that children have acquired during design and technology activities. We have seen how the instances of this strategy increase with age, but we suggest that this is probably because children's understanding of what certain resources can do, and what they can do with them, increases with their experience of designing and making in the classroom. As children's knowledge and skills develop they are naturally able to choose their resources more appropriately. Therefore, although the strategy of *Identifying wants and needs* remains unchanged in nature

through out the key stage, children use it in a more informed way, and it gradually evolves in parallel with their developing D&T knowledge and skills. Because of their increased knowledge base, they are using the same strategy but more often and more effectively as they get older.

When we look to see if this is true for other strategies in this group we find that similarly, strategies concerned with *Focusing on Tasks, Tools and Materials*, seem to be used in the same way by both older and younger children in the study. With limited experience of the tools and materials for D&T, Reception children tend to use their experience of similar tasks at home, to relate to tasks and resources in school. They are inquisitive and like to focus in turn on all the materials provided, investigating thoroughly in self structured play. But as they grow older, groups will choose and gather their own resources, considering fitness for purpose, and will focus *more selectively* on tools and materials, discussing their use and function and checking with adults. They also have firm ideas about appropriate tools for school and home, and about tools and gender. In this way it seems that the oldest children begin to use their experience and imagination to request resources that are not provided, and to conserve materials for later in the lesson, or even future lessons. Moreover, it appears that there is a gradual group consensus regarding order of procedure as children internalise a structure to the lesson. Again children are using the same strategy of *Focusing on tasks, tools and materials*, and this strategy has not changed fundamentally from the one they used when they first did D&T in school, but they are now using it more effectively as their experience of designing and making grows.

The purposes of the strategies of *Identifying difficulties and Tackling obstacles,* is also the same at any age, but children use them more effectively as their knowledge accumulates. Younger groups identify difficulties, but only occasionally act to correct mistakes, and then in a limited way, but they gradually use their strategies to solve very simple problems. For older children, clearly the difficulties change once they have solved them earlier, and other challenges take their place. Furthermore, older children are more confident in their use of tools and materials, and when making mistakes are more aware of where they have gone wrong. They need to use the valuable knowledge and skills they have learnt previously in order to tackle more difficult problems.

Showing and Evaluating strategies also appear to evolve gradually because again accumulation of knowledge about the goals of the task allow similar strategies to be used but necessitate their gradual evolution. 'Short focused evaluative activities looking at commercial artefacts aid product analysis' (Barlex,1995), but experience of real designing, making, testing, and using their own products helps children to really understand the notion of quality. Sadler (ibid) maintains that eventually children should hold a concept of quality roughly similar to that of the teacher, but there may be a case for teachers and children unpacking together what quality might look and feel like in different situations. For, once children have learnt what it is to make a product in D&T, they know

that it needs to fulfil certain criteria in order to be useful. Then, once they have had the experience of designing and making a range of products, children become familiar with the criteria for good quality products and can begin to match their work to their original specifications (Raynish, ibid). In this way, although the nature of the strategy stays the same, there seems to be a gradual evolution from simple showing and sharing in younger children, towards more accumulated understanding of critical evaluation and modification of products at the end of the key stage. Peer evaluation can be both reliable and productive (Wood and O'Malley,1996), and *Showing* strategies may be said to evolve into *Evaluating* strategies. Here we see one strategy gradually being refined. *Showing* and Evaluating are similar, because they both essentially serve the same function, but one has evolved from the other.

Another interesting example of this strategy evolution is the relationship between the strategies of *Practice and Planning*. These now appear to be two strategies and both seem to have evolved from *play*. Play, practice and problem solving have been linked by a range of theorists (Sylva 1974; Bailey and Watson,1998). Sylva's (ibid) research with young children, while they were problem solving during play situations, found that the difficulties that did occur were treated more flexibly as a challenge to be overcome, or information for future tasks. From the present study, it appears that on first entering school, children engage in some rudimentary planning and practising through *playing* with tools and materials. Play is an important function by which young children can safely practise various technical and social skills as training for later (Bruce, 1991; Bruner, 1983; Tizard, 1977). Gradually, children seem to view play activity as practice, and use the words *practice, play* and *planning* in relation to the same activity. They begin to think ahead by practising with the tools so that they can use them later; during what may look like off-task play they plan by placing materials together before joining, and saving materials for later use; and then in a more prospective way, draw diagrams or make lists on paper. But children have done much of this through role play earlier. Young children structure their play so that they can explore new behaviours, materials and ideas, and control their activity (Tamburrini,1982). So, from the child's perspective, the separate strategies of *Practice* and *Planning* have emerged from *Play,* play being used in a less obvious way as children moved through Key Stage 1. These elements seem to refine into separate strategies as children grow older.

Planning and evaluation are clearly key processes within D&T and a great deal of emphasis is given to them. Practice is also essential and may, or may not, be important in other subject areas depending, for example, on whether one agrees with learning 'maths times tables by rote', but certainly Practice strategies are crucial in D&T because children need to master tools to work effectively and safely. It would seem that if children learnt the value of practice strategies these could be transferred across the curriculum. Certainly, the children in Sylva's (1974) research on problem solving through play could repeat, explore and discover novel solutions to problems, and it was suggested that, because

they had to discover principles for themselves, they would be in a better position to transfer this knowledge to a similar situation. It may also be thought that if children learn to plan well, this should be able to be transferred to other situations, if they can see the purpose of the planning. Seeing the purpose of strategies may happen more readily in D&T because the objective of the task is always very explicit as a tangible and visible end product. Similarly, with *Evaluating* strategies, the using and testing of real products has immediacy and authenticity, especially when there is opportunity to modify the work and improve it.

To summarise, we have shown that when using subject specific strategies children are intuitively aware of the need to focus on the task and make links to previous experience, to identify resources, places, and people that will be useful. They investigate through play, practise with the tools, plan verbally, with materials and on paper, show their work to others and evaluate and modify it. But we have shown that with increased procedural and conceptual knowledge, that is knowledge about what they are doing and a certain understanding and skill in doing it, their strategies evolve to be used more effectively. Children's D&T specific strategies depend upon how much experience and expertise they have gained, and their consequent knowledge in the subject. So D&T strategies are cumulative and by looking at each D&T specific strategy in turn we have argued that fundamentally, the core purpose of a strategy is the same, whenever it is used, and at whatever age, but the way it is used will depend on the accumulated knowledge and expertise that the children have acquired through engaging in design and technology activities.

There is a fairly broad acceptance that through practising skills children not only develop procedural knowledge but also conceptual knowledge and that the two necessarily go hand in hand (Harlan,1993; Gott and Mashiter,1991). Kimbell (1996) has remarked that D&T can enable children to 'get access to complex concepts through concrete means'. McCormick (1999) goes further, to talk of technological 'device knowledge' or knowledge of real world mechanisms and systems rather than abstract concepts, but D&T might also include social knowledge. The National Curriculum has made a rather artificial division between concepts and processes, but although they are different in nature, they are inextricably linked. Thus problem solving is an essential part of holistic learning. Makiya and Rogers (1992) argue that understanding concepts of designing and making comes from continually learning and applying new skills towards a gradual process of fuller understanding in an iterative procedure of doing, and reflecting on doing. The present study provides evidence of children constructing strategies through just such an iterative process. They apply skills and use strategies in order to gain knowledge, in turn accessing more knowledge, skills and understanding through doing this and making the original strategies stronger.

Again we turn to our theoretical frame to inform us about the continual learning of the children in this study. Piagetian theory (ibid) was composed to describe the construction of knowledge. As we have said, he believed in a series of paradigm shifts or qualitative changes in intellectual systems with age. Carey's (1986,1992) more domain specific, or modular, view questions whether there is really qualitative change during conceptual development, or just accumulation. But this stress on the endogenous or internal aspect of learning must be modified to include the exogenous influences of culture, environment, and instruction. Vygotsky's (ibid) social constructive view of learning sees the developmental process as social as well as personal. The present study illustrates that as children build their capability by working with and experiencing the tools and materials, and develop their knowledge and understanding by engaging in the task, so their strategies are refined. That is to say, it is through the D&T learning process that these strategies gradually develop. Subject specific strategies evolve and are used more effectively through accumulation of knowledge in D&T, and personal and interpersonal strategies change through increased social interaction.

8.4 Transferable Strategies?

It must now be asked whether children can devise successful problem solving strategies in one D&T activity and then use them in another. Certainly, previous National Curriculum Orders for Design and Technology have assumed transfer (NCC, 1990; DES,1995). The Order (DES,1995) states that 'children should apply knowledge, skills and understanding from the programmes of study of other subjects.' However, there is reference to this at Key Stage 2 in the recent National Curriculum for England (DFEE,1999), requiring that children 'draw on other areas of the curriculum'. But at Key Stage 1 teachers are required to 'ensure that knowledge and understanding are applied', but what do we know about this application? We have discussed how personal and interpersonal strategies are used in many social situations, but what about subject specific ones? It would seem that the strategies which we have called D&T specific are, almost by definition, context dependent because, taking the task as the context, they depend upon what the children are given to do and the type of materials and tools required. We have seen how children respond differently to specific tasks and resources, but are all D&T specific strategies completely context bound?

It seems that there are aspects of young children's strategies that may be slowly transferable. For example, when we consider the different resources used in D&T tasks, we can talk about one material being very much like another, and perhaps gradually, with help from the teacher and each other, children can draw the analogy between different kinds of materials having similar properties, and recall a strategy used in a previous and similar circumstance. For example, when joining wood the older children in the study spoke of choosing one glue in preference to another because it was thick and strong, and would join thick card and so would probably join wood. This indicated that they had

transferred knowledge about the properties of one hard material to similar properties of another hard material, and had taken this knowledge from one D&T lesson to another.

Similarly, another example concerns children's cutting skills. When making moving vehicles a group of six-year-olds had struggled to manipulate the junior hacksaws. It was suggested by the researcher that, instead of putting a great deal of pressure on the saw, they relaxed and pretended they were 'cutting through cheese'. Six months later, when the same children were seven, and making rain forest shelters, one child was overheard giving the same advice to her friend and when asked, recounted the previous situation:

C1: Softest cheese, pretend it's cheese. And do it as soft as you like. (sawing)
R: What are you telling her to do?
C1: Try and, um, pretend it's cheese and .....
R: How do you know to pretend it's cheese?
C1: 'cos you told me last time and I.....
R: Oh, that was a long while ago. And that's quite right because that's what I always say. I say pretend it's cheese. How clever of you to remember.

This would seem to indicate that children can use some ideas that scaffold from one context to another, even over long periods of time. Moreover, later in the lesson, this group extended the cheese metaphor by describing the sawdust as 'Italian or Parmesan cheese, ' as they used it to provide a soft floor covering for their tree house:

C1: It feels a bit like Italian cheese (Parmesan)
C2: Ugh!
C1: That sprinkles on.
R: Ah! What is it you've got that feels like Italian cheese? What is it?
C3: Sawdust.
R: Sawdust, I see.

(Appendix 2: Coded Transcript.)

However, young children's 'context matching' is not always successful and children will slowly learn that tools, materials and tasks are different from one another in many ways, even though they may appear to be the same. For example, when working with clay the children saw that it was soft and malleable so thought that it would behave like plasticine, and used the strategies they had adopted to work with plasticine at the clay table. Despite the fact that, unlike plasticine, the clay would not join easily and quickly dried out, the children persisted in treating it as plasticine even though they soon discovered and discussed its properties. So, attempts by children to transfer learning are not always appropriate. They may make unfortunate links between very similar aspects of

the context, in this case connecting the properties of similar materials without understanding their differences, but having made this association they seem reluctant to relinquish it. It is perhaps even more difficult to unlearn than to learn.

Johnsey (1995) argues for a universal set, or toolbox of problem solving strategies and suggests that anecdotal evidence indicates that pupils at primary level do sometimes transfer skills learnt in another curriculum subject to their problem solving in D&T. But the present study underlines that children's strategy use may be much more complex. Here children attempted to transfer across subject boundaries when they tried to use their knowledge of measuring, taught in mathematics lessons. Continually, as they made shelters, toys, or puppets, children needed to measure for a real purpose of their own. Even though they had been taught how to use standard measures, they rarely used the centimetre rulers provided but reverted to rudimentary use of sticks and markers as commonsense measurement, rather than using formal measurement.

Perhaps here transfer was more difficult for children as they were required to transfer, not from one D&T lesson to another, but from maths to D&T. Boaler's (1998) recent research shows how typically mathematics knowledge is closely tied to the situation in which it is learnt. For young children in the present study, transfer was problematic, even though as for nearly all primary pupils, maths and D&T lessons were taught in the same classroom by the same teacher so that the social context was the same. Transfer must be even more difficult for children in a subject oriented secondary school. Hennessy's (1993) research into pupils' D&T problem solving was done here. She felt that there was little empirical evidence that problem solving capability can be used in different contexts and across subjects, and that particular problems and situations require different approaches.

It is interesting to note here that, when considering successful transfer, the examples that come most readily to mind from this study are of children transferring practical skills or techniques to do with materials and tools such as sawing or manipulating materials. These skills and techniques, such as cutting, joining, assembling and finishing, are essential elements of children's problem solving strategies, and demonstrate their growing knowledge and understanding of the design and make process. One exception to this, where children appear to be transferring subject specific strategies from one D&T lesson to another, is the example of two seven-year-olds using planning strategies. Here the girls constructed sophisticated and complex strategies rather than used isolated skills. They systematically used paper to plan their Thank you card, as they had done in previous D&T lessons but for different tasks, and folded it to exactly the same size. They showed awareness and understanding of this strategy, explaining:

C1: I'm not drawing it exactly. It's just my plan so I don't have to draw it absolutely with everything right.

C2: I'm going to do this part then cut some ribbon. I think I'd better glue it with strong glue - white's (strong white glue) better than this stuff from the tube.

C1: I'm going to change it slightly from the plan when I draw it on the card. You don't see the pattern and I want it bigger. Anyway, I'm going write something down the bottom in the space.

(Y2, Waterfields, Thank you cards)

Here the girls demonstrate not only strategy transfer but metacognitive aspects of learning, or the beginnings of strategic knowledge. Hennessy (1993) argues that this tacit, strategic knowledge includes both cognitive and metacognitive processes, and incorporates problem solving processes and control strategies.

However, in the present study in general, it is examples of children using practical skills or techniques to do with materials and tools in different situations that are most apparent. Inherent in D&T National Curriculum documents is the notion that there exists a core of cross-curricular generic problem solving processes that can be drawn upon by children regardless of content, and that these are readily transferable across subject domains and situations. From the present study it seems that it may be the skills and techniques within the strategies, as active manifestations of children's understanding of the properties of resources, that are most easily transferred at an early age, but this is speculation. Even so, this transfer is a difficult process and depends on children's experience, successful self, peer and teacher scaffolding, and the child's ability to see the essential links between previous and present experience, and to act upon them. Not only is learning context dependent and 'situated' (Gilbert and Watts, 1983; Driver et al, 1985; Rogoff,1990) but children's interpretation of the context, in the present study 'the task or resources', in any particular activity is important in facilitating or blocking the application of skills developed in one context to a new one (Lave,1996). Transfer can be very tentative, take some time, and happen only little by little in young children.

There is little research on how young children begin to take skills and strategies from one D&T learning situation to another. Researchers have been hesitant about tackling this 'big question' and often it is seen as the 'holy grail' of educational theory. Roberts and Norman (1999) warn of the doctrine of the 'design process' as a transferable skill beginning to take hold in schools. They point to myths and ideology masquerading as established fact in D&T research and how this may adversely effect curriculum development. It may be that children find the transfer of practical skills easier than that of conceptual processes, and therefore D&T has an important part to play in encouraging transference of learning. It is important that work continues to try to explain how the processes developed by children in real classrooms are used and transferred.

8.5 Summary

The present study has found that young children use both personal and interpersonal strategies and subject specific strategies to problem solve during D&T activities. Some personal and interpersonal strategies such as *Negotiation* were enhanced specifically by the D&T environment. That is, the context, be it resources or the task itself, prompted social interaction and generated social knowledge, while some subject specific strategies, for example *Showing and Evaluating*, allowed for more general aspects of children's social behaviour to be enhanced. In this way, the two types of strategies complement and build upon each other. Moreover, both types of strategies enhance children's conceptual knowledge, so that children's procedural and conceptual knowledge, is linked to their social behaviour.

As children grow older and move through Key Stage 1, their personal and interpersonal problem solving strategies evolve and change in a qualitative way so that they are essentially different later. Social strategy change may require an intellectual shift which comes from increased social experience and an ability to empathise and work with others. Conversely, development of subject specific strategies depends upon children's accumulation of knowledge and skills, gained from their increased expertise and experience of D&T activities. These strategies change in a cumulative way. Here strategy change may be the beginning of metacognition or an awareness of using skills or strategies, and working towards strategic knowledge.

Children's personal and interpersonal strategies may be used across social and learning situations, but D&T specific strategies seem to be much more context bound, although they may be gradually taken across tasks and other curriculum areas. It seems that for young children, simple skills and techniques or lower order procedural knowledge is most easily transferable across D&T lessons, while use of knowledge from other subject areas, such as maths and science, cannot be assumed. Strategy transfer seems an advanced procedure, the beginnings of which may sometimes be demonstrated by older children at Key Stage 1.

Very little research has been done into primary pupils' problem solving strategies, or their collaboration during D&T. Addressing the Design and Technology Association at the Maurice Brown Memorial Lecture, McCormick (1999) lamented that to date 'there have been few empirical studies of D&T problem solving in the classroom'. There has been little research into children's D&T collaborative problem solving strategies in the classroom, especially those studies that focus on their spontaneous or intuitive behaviour, rather than teacher led interaction. Recent research by Hopper and Downie (1998) has highlighted that teachers have no clear idea of the interrelationship between technological capability and the co-processes it entails. Their understanding of the processes of designing and making often depends on the various models of the design process described in the literature, and these do not reflect the complexity of how pupils undertake real design and make tasks.

As for theorists, within the current debate on knowledge and D&T, attention is being drawn to the importance of the interrelationship of various types of knowledge. Theorists, researchers and teachers need research evidence to inform their work and at the moment there seems to be an 'astonishing degree of consensus' (Kimbell,1999) as to the way forward. The Review of the Curriculum 2000 has bought with it a real desire to work together to explore the unique contribution of D&T to the primary curriculum. The design and technology community is struggling to identify and classify forms of knowledge embedded in objects and related to practical action. There is a lively debate about terminology, and new terms such as 'device knowledge' (McCormick,1999) and 'practical intelligence' (Anning,1999) are being used. In focusing on children's social construction of their procedural and conceptual knowledge during D&T activities, this study may help to distinguish between problem solving skills, techniques, strategies, and styles, and help to explain procedural and strategic knowledge and the relationship between them.

Chapter 9
Conclusion

Introduction

The main question that generated this thesis was the extent to which we could identify and classify the collaborative problem solving strategies that young children use in D&T tasks in school. The basic problem was that in design and technology education, the area in which we knew least was the way young children worked together to tackle designing and making activities. Questions needed to be asked concerning the nature of their strategies and possible strategy change in relation to children's age, tasks and resources over Key Stage 1.

A consideration of the values of design and technology that make it unique, and of National Curriculum change and recent research, outlined the challenge for teachers, and argued for greater professional awareness of children's group strategic action. The theoretical background to the study used ideas on social cognition, and simple Constructivism, to discuss how groups of young children learn from each other. A situated cognition perspective seemed most appropriate to inform the work.

This was a longitudinal study of groups of children, between the ages of five and seven, engaged in design and technology. Qualitative analysis was carried out of children's problem solving in a range of D&T tasks. The results provide evidence of a set of strategies, or taxonomy, used by different groups of children in the study, but these results also provide evidence of similarities and differences in the pattern and sequence of use. It was found that some strategies had remained the same in nature but evolved with age; some had changed qualitatively, while some were simply unchanged; some disappeared, and some new strategies had emerged. The major findings are as follows.

9.1 Major Findings

* There is a set or 'taxonomy' of design and technology problem solving strategies that can be described in a sufficiently general way as to be used over a range of tasks and ages.

* This taxonomy can be seen to comprise two essentially different categories of strategy:

a) Personal and interpersonal strategies

b) Subject specific strategies.

* The two categories of strategy complement and build upon each other during designing and making. The context of the task or the tools and materials determine D&T subject specific strategies, but this practical way of working necessitates social interaction and generates personal and interpersonal strategies. Then, in turn, children's increased

social behaviour allows for subject specific strategies to be enhanced.

* The strategies in the taxonomy are not invariant with children's age, but the two categories, personal and interpersonal and subject specific, develop differently as children grow older:

a) Personal and interpersonal strategies change in a qualitative way so that they are essentially different later. This change comes from increased social experience both in and out of school.

b) Subject specific strategies evolve gradually, depending upon children's accumulation of knowledge and skills, gained from their increased expertise and experience of D&T activities. These strategies change in a cumulative way.

* Although the same taxonomy of strategies is used regardless of task and resources, nevertheless, *the way* the strategies are used is determined by the D&T task itself, and the tools and materials available. Strategies are used spontaneously, either in response to interest in creating the product, or to meeting the challenge of working with new tools and materials. In this way D&T problem solving strategies are context specific.

* Children's personal and interpersonal strategies may be transferable across social and learning situations, but D&T specific strategies are much more context bound. However, at Key Stage 1, it seems that there are some *skills*, within strategies that, with careful teacher and peer scaffolding, may gradually be transferred across tasks.

9.2 Implications for Classroom Practice

These findings may have implications for D&T in the primary classroom. It seems that very young children devise and use their own problem solving strategies in design and technology activities. These strategies appear to develop and change as children move through the first years of school, possibly in response to the new ideas, knowledge and the culture of school. This strategy development seems to depend not only on age, but also on experience of design and technology activities, the types of tasks undertaken, and the variety of resources available. A set of strategies used to tackle problems has been identified, and when using these in the primary D&T classroom, children usually work alongside each other in groups. This is a collaborative environment where general social and subject specific strategies complement each other in an integrated process of designing and making. But it is also a guided environment where children are helped to learn what is new and different about school knowledge and interaction. Teacher or peer scaffolding and bridging is often necessary to help children in this understanding. We still know very little about how this scaffolding takes place, but it may be possible to recognise, build upon and support children's problem solving strategies in the classroom.

9.2.1 Supporting Personal and Interpersonal Strategies

There is a group of personal and interpersonal strategies, to do with children's collaboration, that suggest ways in which teaching might be organised in order to benefit from this type of strategy and support pupils' further work in the classroom. The present study suggests that when they first come to school young children use particularly a *personalisation* strategy. This seems to be an important strategy for Reception and Year 1 children. They ask questions or make comments in order to relate the D&T task to themselves, their personal world, and past experiences. This seems to promote feelings of security and confidence, and helps them to link everyday knowledge and school knowledge. Therefore, it would seem that in order to foster this self scaffolding, it may be necessary to encourage discussion that helps bridge the gap between the technological environment of home and school, for example, comparing tools and materials.

This important continuity between the contexts of home and school may increase children's confidence in building technical vocabulary and skills, and in understanding new ideas. At Key Stage 1, children are still expected to 'explore how familiar things work' and 'evaluate familiar products' in the National Curriculum for England (DFEE,1999). Clearly, encouraging children to talk about the designing and making that goes on at home in the most familiar surroundings, and discussing school and home relative meanings, is a way of inducting children into the specialised knowledge and culture of school. But this may also validate everyday practical learning and help maintain and enhance *personalisation* strategies in older Key Stage 1 pupils, so preventing their decline. If children see teachers acknowledging and valuing everyday knowledge they are much more likely to make home/school links themselves during learning, making for more 'embeddedness'. The legitimisation of children's expertise, often gained from the home community of practice, encourages them to reflect on prior learning of skills and strategies at home, and to use these in school. This in turn may enable not only transfer of practical knowledge from home to school, but may also encourage subsequent transfer of learning from school to everyday contexts.

A *talking to self* strategy is apparent in the way very young children tackle tasks, and again it may be a form of self scaffolding. Young children use this strategy to reflect upon what they have done so far, to alert themselves to what they are doing, and to tell themselves what to do next. This strategy heightens children's self awareness and aids planning. This may be encouraged as children design and make, and may also be enhanced through the use of creative role play areas and construction equipment. In older children this self directed speech seems to disappear but is internalised as thinking through a tricky problem or snag. The strategy of *talking to self* is useful to children because, like writing, talking about action intensifies the reality and enables more objective reflection and evaluation. Self directed speech is a natural activity which is difficult for teachers to promote but can be viewed as a reflective process. Thus children may be encouraged to talk their ideas through with a friend when they encounter

difficulties.

Using *negotiation* as a strategy to discuss aspects of the design and make assignment with teachers and other children, seems to play a large part in D&T activities. The present study found that children responded well when they were allowed some choice in what they designed and made. They liked to use their own ideas, selection of tools and materials, and individual designs. Their confidence was seen to grow during Key Stage 1, from accepting tasks as given in the Reception class, to negotiating the most appropriate tools and materials, working space and partners in Year 2, when they may ask to change the task to suit themselves. Therefore, it seems that flexibility about task boundaries may encourage children to modify and improve their ideas so that they have as much personal and collaborative scope as possible, while retaining some awareness of what is 'allowed' within the constraints of the classroom culture.

Although these may appear to be off-task behaviour, *pretend panic* strategies can include 'dramatic play' which has a practical function. Thus, in the classroom it may be important to recognise that this dramatic behaviour is devised as a worthwhile strategy towards gaining a solution to a problem. The study has shown that children's problem solving strategies grow and change within the school community, but children's own community of practice is essentially that of their peers. Here, most learning is a communal activity and a sharing of culture that creates a sense of belonging to home, school and local community, but children have their own special child culture that adults rarely enter into. Here designing and making is intuitive through children's play. They draw, construct, and role-play spontaneously, and they may extend this drama to D&T lessons in pretend panic strategies.

The present study suggests that D&T is a potentially rich environment for collaborative learning and that children use *sharing and cooperating* strategies to support this learning. Very young children may sometimes ignore offers of support from others, but as they become more experienced they begin to value first manipulative help from peers, and then intellectual collaboration with a partner. By Year 2 they will appreciate opportunities to choose working partners. The study has shown that children will ask each other for help and, as they grow older, will gradually be able to distinguish between the type of support best provided by peers, and the kind that may be requested from an adult. However, they seem to respond to the aspect of the task, be it the end product or tools and materials, that offers the most novelty and challenge. They are enthusiastic about tackling new ideas and resources and may set themselves really tricky problems. Careful intervention is important here so that they are supported in seeking help and, although guided towards choosing realistic problems to solve, are not tempted to favour easier options. In this way they are encouraged to collaborate as problem solvers and problem seekers.

9.2.2 Supporting Subject Specific Strategies

There is a group of subject specific strategies used by young children to do with *focusing on task, tools and materials*, *identifying wants and needs*, and *tackling obstacles* that suggest ways in which teaching could be organised in order to benefit from this types of strategy, and support children in further work. Considering, first, the *focusing on task, tools and materials* strategy the children in the study directed their attention to the product they would design and make and the resources they would use to do this. While focusing on the task itself, for example, children working with clay showed that sometimes their products were 'transient' in that they could be created and recreated a number of times during one lesson. Children often rolled the clay products into a ball and started again in a different way. At other times, when designing and making puppets or toys, the idea of making a 'prototype' seemed inappropriate as they considered everything they designed and made intrinsically valuable and an end product in itself. This may need to be kept in mind at the start of the lesson, when setting D&T assignments, to help children to think about what they want to design and make, and to discuss whether this is a model, prototype, or final product to be kept and used .

When *focusing on tools and materials* as a strategy, young children may concentrate so intently either on new tools that they are using or on interesting materials that are provided, that sometimes, because of novelty or excitement, they forget the objective of the task. They may focus on these by structuring play in order to explore the properties of the materials, or in order to use the tools. Clearly, it would be crucial to ensure that this enthusiasm for the resources is maintained and play is nurtured, while bringing children back to the main task would respect the need to achieve the goal. However, once over the novelty of the tools and materials, children will still need to practise with tools in order to enhance their own skills, or investigate materials in order to understand them better. The use of such a strategy permits them to acquire skills in the use of tools and accumulate knowledge about materials they are using. The National Curriculum for England, Design and Technology (DFEE,1999) provides for *'focused practical tasks'* so that teachers can help children practise skills to use in longer design and make assignments, but it would be helpful to create tasks which have a sufficiently open-ended nature, so as to allow children to spontaneously focus on tools and materials as part of the overall goal.

In many D&T problem solving situations children may appear to want time to do unplanned or seemingly off-task activities. It would be important to ascertain the purpose of these since they could be strategies devised by children to, as just mentioned, investigate the nature of materials, or acquire more skills, or gather and conserve resources. It is not always easy to diagnose why children want to 'follow their own agendas'; however, a little space and opportunity for discussion could reveal reasons that demonstrate whether or not they are working towards the planned goal. The strategies identified in the present study show that clearly it is crucial that in D&T pupils take initiatives, make sensible choices within a set of possible alternatives, and think ahead so

as to anticipate snags or difficulties. Sometimes, the way that they do this may look very different from how adults would work, but children can be very inventive and often surprise teachers by finding novel ways of designing and making.

Some of this thinking ahead occurs when children use a strategy to *identify wants and needs.* Before they begin to work, they need to select resources from the range available. At first, children's choices can be very subjective, such as choosing their favourite colour, and they will want to use new and interesting resources regardless of their fitness for purpose. Providing opportunities to explore the sensory qualities of materials and the use of tools before children start to discuss what they will make, may enable more effective choice. Children will be drawn to certain materials and value and conserve these. These conservation techniques can provide a fitting introduction to work on understanding the values embedded in technological advances. In this way, young children, even at Key Stage 1, may be helped to explore values, the differing priorities of users, and how value judgments are made. The different values of users can also be discussed when children need to decide what kind of product they might make and how it might be used. Discussing children's wants and needs as users at the start of the lesson helps them identify simple design criteria which they can refer to throughout the lesson to evaluate and modify their work.

The study has found that during problem solving young children can acknowledge difficulties and find ways of *tackling obstacles.* The question of when to intervene to scaffold or give advice is a difficult one, and it very much depends on the teacher's special knowledge of the children concerned and their capability. This 'intersubjectivity' will allow teachers to choose the right moment to offer guidance, and to know if it is appropriate to actually work with the children in co-construction, or to demonstrate 'device knowledge'. The young children in the present study expected to use tools that were modern and matched the level of technology that they were accustomed to outside school. They also demonstrated that material they found attractive and exciting to work with encouraged their conservation skills. Using the appropriate technical vocabulary at an early age can be important. The children in the present study were aware that school technology can sometimes appear outmoded and even archaic. Providing equally modern tools and materials to those they see at home and in the work-place can encourage children to draw parallels between school and everyday procedures.

As children make progress in D&T and move towards the end of the key stage their problem solving strategies progress from structured play to include *practice and planning.* Children see the need to practise skills before beginning to design and make, and will readily engage in focused practical tasks if they see that these will support subsequent D&T assignments. They use their problem solving strategies to begin to understand how the characteristics of tools and materials relate to how they are used, or how they need to select different types of glue to join heavy and lightweight materials. They begin to understand form and function, and see that the shape of certain clay tools

dictates how they might be used. They make informed choices when planning verbally, plan by placing materials together, and start to make lists and draw images and labelled diagrams. Therefore, it may be important to provide for different ways of planning, such as verbal planning and picture planning, mark making and placing materials together for design representations. In this way they may begin to see designing and making as an integrated, organic process that grows gradually. However, children create plans but do not necessarily follow them. They may need support to discuss what can realistically be made within the constraints of time, resources, and their own expertise, and would need to be able to change their plans as they design and make.

The present study has shown that until children have a certain amount of knowledge of resources and a certain skill in manipulation, their ideas about what they want to make, or what they need to make it, cannot progress. Their strategies depend upon how much D&T they have done and the knowledge they have gained; they depend on their experience and expertise in the subject. So, knowledge, skills, and strategies are cumulative. Therefore, it is suggested that children will not necessarily respond successfully to work at the National Curriculum prescribed level for their age, if they have had little previous experience of D&T. In order to plan successfully they need previous experiences of resources or similar tasks. Sometimes, by inviting professional designers and makers into the classroom and visiting their workshops and studios, it may be possible to use examples of the flexible planning procedures of real designers and makers in the local community, many of whom rarely plan on paper.

The study demonstrates that very young children often show and share their work openly, using *Showing and evaluating* strategies, and can respond to evaluation and modify strengths and weaknesses in design, but that sometimes pupils can be sensitive to the 'opinion' of others. It is important to children that they get positive feedback on their products so that their confidence in *showing* as a strategy is maintained as they grow older. Often young children are reluctant to modify their work as they are satisfied with the outcome regardless of the original design specification or the opinions of others. This can make evaluative activities difficult at times. The children in the present study showed that, at Key Stage 1, shared evaluation can work well and children may be less reluctant to improve their work if it is in response to peer assessment. Therefore, at the end of the lesson, it may be appropriate to pair children with a 'critical friend'.

9.2.3 Supporting Strategy Transfer

The present study suggests that children's personal and interpersonal strategies may be transferable across social and learning situations, but that D&T specific strategies are much more context bound, although at Key Stage 1 some skills, rather than complete strategies, may be gradually transferred across tasks. Consequently, the question of what can be done to support possible use in other learning situations arises.

Firstly, considering children's personal and interpersonal strategies, it is suggested that these are transferable across social and learning situations, and that

where this transfer exists, strategies change radically in nature as children mature. Therefore, it seems possible that collaborative environments may be more likely to encourage transfer because teachers and peers can engage in scaffolding that enables children to see patterns and links across social contexts. This scaffolding may take a discursive form, where teachers help pupils make links with previous work of a similar nature, or an organisational form, where they place children within a social, resource, or task environment designed to facilitate peer scaffolding. It seems certain that creating a classroom ethos where young children feel confident enough to pass on their ideas to others, or to work cooperatively with a partner, assists peer scaffolding.

Secondly, it has been suggested that children's D&T specific strategies are much more context bound than their personal and interpersonal strategies. It must then be asked what can be done to support transfer here? It seems that more rapid transfer of knowledge specific to D&T would obviously accelerate learning in the subject, and successful scaffolding may aid this. But in the present study, the D&T activities and data gathering in the classroom were undertaken without heavy guidance from the researcher. Generally, it was perceived to be important that children had time and space to engage in peer scaffolding, to devise and use their own intuitive strategies, and to attempt to transfer knowledge and skills from one lesson to another. However, from the safety point of view, some scaffolding was necessary when children were working with tools that were new to them or when they were inexperienced in their use, but this was limited. Perhaps because the researcher rarely intervened, this had interesting outcomes in terms of transfer. When focusing on the instances of scaffolding, it was found to be skills, concerned with use of tools and materials, that the children found most readily transferable from one D&T learning situation to another.

9.2.4 Supporting Transfer of Skills.

From the present study it appears that at Key Stage 1 *some skills,* rather than complete strategies, may be gradually transferable across tasks. Consequently, the question of how this transfer may be fostered in the classroom arises. The instance of peer scaffolding, when one child was learning to use a hacksaw and was advised by another to 'pretend you are cutting through cheese', demonstrates the transfer of a cutting skill from one lesson to another. The scaffold originated from some months before when the researcher had suggested to a child who was experiencing difficulty with the hacksaw and was pressing too hard that she relax and pretend she was cutting through cheese. In this instance the skill of using a hacksaw to cut through wood was transferred via scaffolding from teacher to child, and then much later from child to child. It appeared that the novel imagery used made the researcher's original advice so memorable that the child later used it to scaffold her friend. Bruner talks of the successful scaffold making it possible for the child to internalise knowledge and convert it into a tool for conscious control, and points to the adult acting as a vicarious form of consciousness until such a time as the learner is able to take ownership. Here the child, in order to do this, had not

only listened to and observed the researcher's scaffold, but had internalised it and made it her own. It was this ownership that had allowed her to pass it on later to peers. Group ownership had then prompted its extension, because the cheese metaphor was then adopted by other children as 'Parmesan cheese' when discussing sawdust. This was a real Vygotskian example of how, little by little, the responsibility moves from the adult scaffolder to the child, who takes over the task of guidance. However, it seems that cluing or making links through the use of novel or amusing imagery may stimulate children's interest, and make the learning attractive and unforgettable, so prompting ownership and assisting transfer of skills from one context to another.

Similarly, the use of *action and gesture* by teachers seems to aid skill transfer. The sheer physical nature of the D&T activity, where the problem centres around a concrete object, may enable thinking, learning, and remembering. Many cognitive activities in everyday life are closely engaged with the physical world. In the present study the children modelled actions with tools or materials when making a point in discussion. A child 'acted out' using an electric saw when describing the more modern technology he had seen used at home, and another demonstrated folding techniques in the air when scaffolding a friend who was making a sunshade from a circle of card. Here folding skills were successfully passed on from child to child, and also used later in order to make a lampshade. There were other examples of peer scaffolding through gesture, and then the transfer of those skills to another occasion. Thus, action and gesture may not only aid learning but help learners to reflect upon and reinforce it.

Learning and using skills and techniques concerns working with and thinking through concrete objects such as tools and materials. Thinking through discourse is discussed widely in socio-cultural literature, but our theoretical frame has shown how both Piaget and Vygotsky emphasise thinking via other media, such as objects and tools. We have seen how young children's problem solving strategies are intimately connected to the task, tools and materials of the physical context. Transfer of learning from one context to another is not always successful. In the present study, when manipulating malleable materials, children's attempted transfer of skills from working with plasticine to working with clay demonstrated the difficulties of trying to match two different contexts. In this case, learning about the properties of one material was transferred but needed to be modified to fit an apparently similar but essentially different material. Experienced teachers rarely teach two apparently similar, but essentially different topics side by side, because children may associate and confuse them. The children here had seen the similarities between the materials but not the differences. They had understandably attempted to match the physical context.

Helping children to match contexts may foster transfer of skills. The children in the present study used the word 'sparkle' for tinsel, and attempted to conserve glue in the fold of a paper towel, as they had done successfully with glitter. They tried to make links across learning situations for themselves, and to relate similar materials and techniques to each other. Thus, helping children to understand not only similarities but differences in

appearance, texture and function of materials, and to focus in turn on different types of hard, soft, and flexible resources, may help create appropriate links. Importantly, making explicit children's intuitive attempts at transfer may increase self awareness, help them to feel secure in what they know, and to repeat skills in a different learning situation.

Providing new and exciting materials and challenging tools seems to foster skill transfer. In the present study conserving skills were repeated in different situations where children valued the materials provided. This was most apparent when they used glitter. Three seven-year-old children discussed how they could use it properly now because they had practised last time, and explained how they had put the glue on first, then the glitter, then shook the card onto the newspaper so that all the glitter fell off, except where the glue was, then folded the newspaper and funnelled the spare glitter back into the container. This complex conservation skill was learnt in one lesson, practised, and then transferred, used and recounted to peers in another lesson. However, this is another example of transfer of skills rather than strategies. It is important to repeat that this section has focused on some ways in which it may be possible to foster the transfer of children's D&T skills or techniques. Strategy transfer seems to be more complex and problematic, and it seems that we still know very little about how this may be supported in the D&T classroom.

9.3 Further Research in this Area

The question that needs to be asked now is where we should go from here? What further research would build upon and extend the present study and how might that translate into classroom practice? Although there are many areas that have not been tackled by the present study and that might provide further work, it seems best to base any further research directly on the work done so far. Strategies have been identified that children use when working together in groups, or alongside each other in cooperation, but individuals were not considered here because that was not part of the focus of this study. It does not seem relevant now to try to highlight the strategies of individual children or to ask what would happen if a child were asked to work on a D&T task completely alone. Of course this would mean that children would not use all the identified social strategies, would be left wondering where to go for help, and would focus only on subject specific strategies. Contrary to this, as the prime concern of the work so far has been to focus on groups rather than individuals, then any further research should continue from and build upon this aim.

To begin, one might look at the nature of the group and how this affects children's problem solving strategies. In the present study the nature of the group was not in question and the only group commonality was age, so there are many questions that could be asked about the make-up of groups engaged in D&T. The obvious first distinction is that of age. The work has focused on a certain age group, that of Key Stage 1, so perhaps it would be appropriate to continue the study by looking at the strategies of groups of children at Key Stage 2. Another distinction is gender, and questions could be

asked about the problem solving strategies of single sex or mixed groups, or mixed groups where the balance varies. However, the gender debate has been rehearsed many times in areas of both D&T and science education, and perhaps other questions are more appropriate. Similarly, questions could be asked about the ethnic mix of groups and how this might affect problem solving. Certainly it would be interesting to focus on groups from cultures that are rooted in trade or craft traditions and ask how this might influence the strategies they use, although much would depend upon how long they had been living in this country and whether the traditions had been maintained in their adaptation to a different environment. However, such research may again begin to focus on personality and psychological differences of individuals within a group, or social aspects rooted through D&T education, rather than research that is specific to design and technology as a subject.

What then are the questions that follow naturally from the results of the present study and that might penetrate, deepen and extend the work? Questions that seem most worthwhile are those that concern the design and technology specific strategies themselves. It would be particularly interesting to take a much closer look at these strategies; at how each strategy is used by children; and at the relationship of the tools and materials to the manner of its use.

The present study has identified a set of generic design and technology subject specific strategies but we have seen how these are context bound. Although some skills rather than strategies are fairly easily transferable across D&T contexts it seems that the strategies that are specific to D&T proper, rather than to the general social situation, are bound to the context of the task. They are bound to the physical environment in terms of the classroom or school context, but that physical context includes the tools and materials used in the task. Consequently, although children use the same type of strategies across contexts, that is for different tasks and resources, these strategies are nevertheless *used in a different way depending on the type of resources,* but we do not know the nature of this difference. We do not know *how certain strategies differ* depending on the tools and materials used by children. From the present study, the resources seem to influence the way the children work because it appears that children adopt either a product or process focus depending on the type of tools and materials they use, but we do not know how or why this happens and in what ways resources may colour children's strategies. Personal and interpersonal strategies may differ slightly from context to context, but broadly they are used in the same way by children, however, the same D&T specific strategies are used differently in different situations and we do not know how this happens.

To begin to explore this research agenda further it may be interesting to discuss certain subject specific strategies in the light of this possible work. It might be interesting to reflect upon the tools and materials used in the study in relation to the identified strategies, and also to speculate about the use of other resources not used in the present study that might increase the range of the work and provide further scope for analysis. The work so far has looked at the role of resources concerning certain hard,

flexible and malleable materials, but within these categories a fairly limited range has been used by the children. The resistant materials used were mainly types of wood and card, with some plastic and found materials, beads, cotton reels, sticks, pegs and wire. A wider range of flexible materials included paper, tissue and tinsel, assorted textiles, ribbons, buttons, wool, and sequins. It has been shown how materials can prompt certain skills and strategies. For example, glitter encouraged children to use conservation skills, and balloons prompted certain investigative strategies, but it was not possible for the groups to work with food and it has been suggested earlier that certain types of food might require different strategies not yet identified. Clay was the only soft and malleable material used in the study, and children drew parallels between the use of clay and previous work with plasticine. It would be interesting to see how they use subject specific strategies when making dough for pastry, biscuits or bread.

To begin to explore children's use of certain D&T subject specific strategies in relation to working with food it seems that, for instance, the strategy *tackling obstacles*, may be used quite differently by children when they work with this material. Certainly, the obstacles that children encounter appear to be quite different when children use food from when they use wood or card, but is this really so? Children need to worry about health and safety problems and concerns surrounding hygiene when working with food but is this more to do with skills than strategies? The general skills needed might be similar in terms of joining, combining and separating, measuring, marking and cutting, and decorating and finishing. These skills seem generalisable because children need to join different types of hard materials and different foods and to cut, and decorate both. It seems easy to discuss similarities and differences in the way skills are used across resource contexts, but what about strategies?

Perhaps the essential difference in using strategies to work with food lies in the transient nature of the material. Wood, card, fabric and other materials have permanence and rarely change in nature as they are shaped and manipulated. However, food can act on food to create new transformations. Food, perhaps more than any other material, is subject to change in structure and consistency as it is worked upon. It can change its appearance, can be combined to disappear within another food, become unrecognisable, change in colour, texture and consistency, be heated or frozen to expand and contract, and become liquid or solid. When children work with food such as mixing jelly, fruit drinks, or soup, or making bread, pizza or sandwich snacks, they may need to use familiar strategies in unfamiliar ways. When they design and make with food it seems reasonable to expect that the chemical and visual change that take place may make the way they use strategies very domain specific. This may be because certain chemical aspects of investigating the materials may always be uppermost in children's minds. In contrast, working with wood may prompt ways of using strategies. This is speculation but it seems worthwhile to explore these areas in future research. Focusing on food may help to explore how the application of problem solving strategies within different domains may have a different realisation.

To go further, the vocabulary, feel, taste and smell will vary when preparing hot or cold food and may generate many ways of using strategies. For instance, it might prompt children to use *Showing and Evaluating* strategies in different ways. The familiarity of needing to respond to food in everyday life, both in school and in the home and community, may have encouraged children to become practised consumers. They may know and can express their food preferences and the reasons for them. They may understand aesthetic values in that the appearance of food is an issue at mealtimes, and to some extent they may also have a fundamental understanding of economic considerations and of the part cultural values often play in food preferences. Young children may have an early appreciation of the environmental and social aspects of food preparation, and understand the need not to waste food and to dispose of it carefully. Therefore, because they are practised evaluators of food, they may use *showing and evaluating* strategies in different or more sophisticated ways.

However, looking in detail at designing and making with food, for example, it seems that materials are important in the way strategies are used but perhaps tools are even more crucial. The tools used in the present study were those associated with hard materials, clay modelling, and textiles. It would be interesting to see if the inclusion of food tools such as slicers, peelers, choppers and graters would impact on the way children use strategies. The study has indicated children's awareness of modern technology and how tools may differ in the home and school. We have seen how school woodwork tools can seem archaic to children, but usually food tools in schools are hygienic and modern because food processors and antibacterial chopping boards and cleaners are in general use in the home and can be easily brought to school. Consequently, the use of modern food equipment might influence the way children work. Further research might be done into whether different types of modern tools might prompt children to use their strategies differently.

If we accept that the strategies are influenced by the resources in such a way that they affect strategy use, then, although tools may be changed to become more refined or work better, materials usually stay the same and are always resistant. In design and technology tools may be helpful in shaping the materials but the materials themselves are the constraints on the strategies. It is the food, wood, card, or clay that resist manipulation to a greater or lesser extent. The present study has shown that it is the resources that affect the way the strategies are used, but it has not shown exactly how this happens. We have identified a set of generic strategies but have not gone further to analyse the elements of each strategy in relation to how, when or where it is used. We have not asked what the same strategy may look like when it is used in different resource contexts, what are its component parts and what specific skills, techniques and other aspects interact? We now need to identify and classify strategy elements in different resource situations. To go one step further we might then ask whether, if the resources become more and more specialised and the strategy is used in a radically different way, then does it eventually change in nature to become a different strategy? Furthermore, the strategy

may become sufficiently different from one situation to another so that eventually it looks like a new strategy.

These questions are pertinent to this thesis. Here interpersonal and subject specific strategies have been identified, but although much is known about social strategies, very little is known about problem solving strategies that are special to design and technology as a subject, and how they emerge, develop and change. The suggestions here are a set of ideas that emerge from and build upon the present study and inspire further work. They pose questions that encourage strategy analysis at a deeper level and ask about how tools and materials interact with strategies to solve problems and achieve a product. They reiterate the Vygotskian question of how tools work upon materials to influence learners and how wide ranging materials prompt learners to react in certain ways, modify their strategies and use them differently.

However, if different tools and materials prompt different ways of using strategies, and food is discussed here purely as an example, then this has implications for classroom practice, both for the teaching of D&T in primary schools and for attempting the suggested research agenda. The ideas presented here suggest that the type and range of tools and materials used in the classroom need to be extensive in order to encourage variation in children's strategy use and strategy development and change. If this is so, then teachers' subject knowledge concerning the use of tools and materials needs to be extended, and they need access to more modern D&T equipment in schools. It would be important for teachers to have the knowledge, skills and confidence to work with children using a wider range of hard, resistant, malleable and soft materials. They also need to press manufacturers to supply more modern children's tools such as battery operated drills and safety power saws, cold glue guns, automatic junior food processors and blenders, and children's sewing and knitting machines. Of course, this may call into question the maintenance of traditional craft skills, so it would still be important to maintain a balance of traditional and modern tools and equipment.

Furthermore, before attempting the suggested research we might ask to what extent the practice of teachers in the classroom is influenced by such work. Before we ask how children use their strategies in different resource contexts it would be useful to have some idea of the impact of D&T research on classroom practice. The present study has discussed different types of subject knowledge but not how this knowledge is gained by teachers. Is it from initial training, INSET, other teachers, professional designers, teachers' own home culture or present community of practice, or from their reading or own research? Are primary teachers influenced by studies such as the present one? There is a new and growing national research community in D&T, and many publications and journals are now directed towards teaching and learning in the subject. The subject association (DATA) is particularly strong and active, resulting in a growing exposure of D&T teachers to pedagogic research. Does this suggest that many view such research as potentially relevant to their practice, or do they find it just interesting? Perhaps more attention needs to be paid to how teachers receive and interpret research evidence, and

how they view it in relation to their values, beliefs and general learning objectives. What part, if any, does research evidence play in teachers' knowledge base, and do they see this as relevant to their classroom practice?

9.4 Summary

Design and technology concerns how we use tools to act on materials to control and change the world. The research reported here has gone some way in answering the original research questions, but this has prompted a further set of questions. These concern how general strategies might be applied by groups of children differently when they use different resources. They ask how children might apply strategies in a very different way when using types of hard, soft and malleable materials, and how the type of tools they use to act on these materials makes a great difference. The present study has considered the role of materials in prompting children to focus on certain aspects of D&T tasks but it has not explored the role of tools acting on those materials or considered the notion of materials acting on materials to create new transformations. Because technology is an exciting activity, materials can act on each other, or tools act to change materials, or materials can resist tools and new tools be designed and made. This is how technological progress takes place. D&T in the classroom concerns this constant interaction between the tools, materials and children, but children cannot impose themselves on the material without the tools because materials are resistant. We have seen how different materials are resistant to a greater or lesser extent and how the children in the present study found means or strategies to tackle this. They were required to find ways of being inventive and creative by working and shaping these materials with the tools provided. If learning through design and technology activity revolves around the need to devise strategies to manipulate tools to shape materials for a purpose, then we still know very little about the way children work together to solve these problems. A great deal of research remains to be done.

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Appendix 1

Example of Uncoded Transcript

(Year R using flexible materials)

Gorden Park Primary School **3/11/92**

Reception, Oldest Group

Task: Greeting Cards

Group: Helen, Kim, Orin, Alison, Chris, Nikki.

R: Researcher

R: What's in here, do you think? (shaking box of old Christmas cards)

O: A book?

A: No, cards. (feeling the box)

H: Birthday cards.

O: No, Christmas cards.

R: Why do you think Christmas cards?

C: Because it's Christmas.

H: And it's my dad's birthday.

R: Yes, it's Christmas.

A: And that's why we're making them?

C: And when we've made our cards what will we do with them?

O: Are we allowed to make two?

R: Let's make one first and then we'll see if we have some more time.

A: Good.

R: So when we've made our Christmas cards what shall we do with them?

O: Hang them on the wall?

R: Hang them on the wall?

A: No, leave them to dry.

C: Take them home.

R: What will we do with them at home?

O: Put them on the Christmas tree.

R: Yes, when we've made a Christmas card what do we do with it?

C: Give it to people.

O: I could give it to my mum.

C: Your gran.

H: I know, our nanny.

C: I made a card before.

K: First we got a card and we drawed a picture on a card and we ...

N: We coloured it in.

O: We put sticky on it.

H: What can you draw on Christmas cards?

C: Birds.

R: Any birds?

O: Only robins.

H: Angels fly.

C: You put them on Christmas trees.

R: Shall we look at the cards in the box? Look there's your idea Helen. There's a Christmas tree.

H: Oh look a teddy bear.

A: That's a star. That's my one. (idea)

O: Oh, food on it. (surprised)

R: Yes, you could put food on a card.

K: That's my idea. That's a dog.

O: Oh God, you can put God on it.

H: That's a new born Jesus.

C: Ahhhhh!

O: And Jesus is God.

O: Flowers.

R: Yes you can put flowers.

C: MMMMmmmmm!

R: So there's lots of ideas.

N: We're wasting our time.

R: You think we're wasting our time?

A: Yes, let's get on!

R: You think we're wasting our time. What would you like to do?

H: An angel. (children saying that looking at bought Christmas cards is a waste of time.)

C: A teddy bear.

A: A Christmas tree.

K: I want to use the glitter.

K: So do I.

N: So do I.

A: Actually I don't want to do a Christmas tree.

R: I see..... you want to think about it.

N: I know how we might start.

H: I'm going to do an angel too.

C: I'm going to do a little one.

A: We have to draw them and then we can decorate them.

K: Can I have some pink card? (considering the pile of card and choosing a colour)

N: I want a pink one. (handing out card to the group at their request)

A: I want a pink one.

O: I would like an orange one.

K: Pink! Pink! (Child not finishing handing out card to group but beginning to work on own

card)

H: Do we fold them?

C: I haven't got a card.

R; Do you know what that colour is?

K: White, white.

O: Indigo! (laughing)

R: Indigo! (laughing too)

O: What about a pencil?

C: I'll go and get some. (C. moving to get some pencils but seeing that another child is going to get there first so gives up)

H: I'll go and get some. (H striding to get pencils)

C: Here!

H: Here they are. (H returning with pencil pot)

A: Put them in the middle so somebody can reach them. Everybody can reach them there.

A: This is how you do a fairy ... I mean an angel.

H: I'm drawing an angel... there and an arm ... oh I've done it wrong....I did it wrong!

N: There and there and now I'm decorating it ....with glitter ... ahhh ... glitter.

R: What do you need to do?

H: Make wings.

C: Can I have some scissors?

H: I've done it wrong. How do you do it? (H making mistake and looking at her friend's drawing for help)

A: What's that?

O: Doing a Christmas tree.

H: Oh, I've done it wrong.

K: Rub it out. (another child)

H: Rub it out.

C: Anyone got the rubber?

K: It's too small. He can't put decorations on it if it's too small.

A: Look, my angel. I've done my angel. (A offering her work for evaluation by the group)

C: That's good.

O: Don't look like an angel to me.

N: Looks' like she's holding a flower or an arrow.

A: Yes, a flower.

H: Yes, or a handbag.

A: MMMMmmm, a handbag.

K: Oh, look, it's gone all messy. (Child putting too much glue on her card)

N: Wipe it.

A: Anyone got a tissue?

A: I know you can get a new one. (Child offering friend a new piece of card)

C: Can I do my decorations?

R: Yes.

H: Angels are too hard for me. (Child giving up trying to draw an angel and starting a Christmas tree instead).

A: They're not too hard for me.

N: You just need to get used to them, that's all.

K: My teddy bear

C: Oh ..... (Child offering her work for evaluation by the group)

Group: Ahhhh.....

H: That's a lovely teddy bear.

C: It's all woolly.

A: Don't put too much glue on it.

C: Have some of that? (Child pointing to the glitter)

R: Some of this or that?

C: Have you got any green?

R: MMMmmm is there any green glitter?

O: No, I want a balloon.

C: A little bit of blue glitter.

A: The little Lord Jesus la...la...la.... (singing a carol)

R: Do you know how to use glitter?

C: Yes,if I can pull the lid off. Can you pull this lid off? (Child shaking glitter onto the card without glue then realising that it would not stick)

N: GLUEEEEE... (laughing)

K: Yes. you didn't put glue (laughing too. Whole group watching friend's mistake)

A: Gold might be the colour. I mean silver.

N: I can't open the glue!

H: It's very shiny and and sparkly.

N: Put the glue on first ...(Child putting glue on card first exactly where needed then carefully sprinkling glitter)

N: Only a little bit ... I'm going to get some more glitter ... there and there ... ahhh.

C: Can you pass the glue?

C: OK. Wait a minute.

K: Oh, too much on again.

N: Shall I wipe it off?

C: I need the blue glitter please.

N: Put that back in. Look wait a moment. (Child using lid of glitter tube to scoop up spare glitter and put it back in tube)

H: Are these new? (Child replacing lids of felt tips)

R: MMM

O: I've got some at home.

R: What have you got there Alison? Is that glitter too?

A: I don't know.

K: It's tinsel.

C: You can make decorations like little wings. Can we use some?

H: And this?

C: Can I have only a little bit because of the other children?

R: Have you given up with that? (Child pulling paper from his sticky fingers and throwing it in the bin)

H: Yes, cos it makes me all sticky.

R: Yes so you're going to give up with that green paper and use something else are you?

C: Yes, blue.

R: Ah, that's interesting. What have you made there?

H: A little pot for my Christmas tree ... and my daddy said let's put some decorations on it and I put on the fairy and had a wish and I wished that I didn't do anything silly.

O: Can I have some of this string? (Child choosing a roll of ribbon. Picks it up and looks through the hole in the centre.)

R: Not quite like string is it?

O: Ribbon. A kind of ribbon.

H: Who's got the silver for Orin?

A: Something's missing here.

R: Yes, what do you need?

A: The lid so the glitters not wasted.

N: Yes, pick it up and put it in. I've got a good idea .... I think that if you put something here .... you can put the glitter in it and pour it in there.

R: Ah! What do you mean?

N: Well if you get a paper towel you can pour it in.

R: Oh I see you brush it into a fold of the towel. That's a good idea.....

N: I think that if you put something here .... you can put the glitter in it and pour it back in the tube.

R: Ah! I see.

N: Well if you get a paper towel you can pour it in.

R: Oh I see you brush it into a fold of the towel. That's a good idea. Will you do that? (Child making a funnel for glitter with paper towel and pouring it back into the tube.)

O: I can make a balloon.

K: My mummy makes balloons on cards. I help her blow it up. First you stretch it then you blow it.

R: That's right. So you're trying now to blow that up?

O: If I can't do it will you do it?

C: What can I put on now? I want to look in the box.

A: Can you pass me some of that? (Child considering sequins)

R: What are they? Do you know?

C: They look like flowers.

R: Yes, they look like flowers. Anybody?

C: Kind of decorations.

R: They are .... sequins.

C: I can't find any that I like. What do you think? umm.....errr....

K: This one or that one?

C: ERRR...ahhhhh.

K: What do you think?

C: Yes, no, no.

A: One of these, yes.

N: That's nice.

H: We've all started decorating we have.

N: We didn't know we were decorating did we? We thought we were still drawing. We've nearly finished!

O: I can't do it. Help! (Child trying to put sequin on his card.)

O: I didn't have any glue that's why.

O: Put the glitter (sequins) on there and there.

K: I f I put the glue you can put them on, what do you think of that? No?

C: No! (Child rejecting help and wanting to do it himself)

K: Happy Christmas to you la...la...la (singing)

A: I do not think you can put tinsel on.

C: Where's the pink glitter?

H: I don't know.

N: Yes. I just need the wiper ... wiper!....wiper!

A: We should be finished now!

C: I just want to ...

K: Yes we have.

O: I need to put one there and one there. (Child rushing to use the silver stars)

O: Nothing. Just one little star here then I've finished.

R: Alison where have you been?

A: Trying the tinsel on my friend's head.

R: Trying the tinsel out on someone's head? How did it look?

A: Nice, yes look (shows tinsel on child's hair)

K: Glitter ... glitter ... Quick

H: Can you put some glue on there ... glue on .... glue on.

N: Now I'm getting the blue ... no the gold.

K: The gold ... the gold ... it's too much ... ohhhh.

A: Quick! it doesn't matter ... quick put the lid on you'll waste it! (urgently)

H: Where's the pink glitter? pink ... pink....

R: There it is.

H: OHHHHH who knocked that over?

O: Not me.

K: A star, look at this..

C: Can I do some felt tipping now?

R: Yes

K: Put that there.(advice to friend)

O: It's one of the little stars.

R: That's lovely.

C: It's my teddy at home ... he's multi-coloured the same colours as mine.

A: Is he saying happy Christmas?

R: Do you think that's a good idea of Alison's?

A: You could write it there.

R: How would you write it up there? Who's going to write it? You are? (Child beginning to write at the top of her card.)

C:Yes...h (sound)

R: Right.

C: a ....(sound)

R: Yes, what next?

C: p....(sound)

R: Another p. HAPPY.

C: Y (sound)

R: Good Happy .....?

C: Birthday.

R: Happy birthday? Happy....? (laughing)

C: Christmas. (laughing)

H: Where's the blue?

R: I think you've all finished now.

C: Has anybody got the rubber? This is my last word.

Appendix 2
Example of Coded Transcript
(Year 2 using hard materials)

Gorden Park Primary School
Y2, Youngest Group **4/7/95**
Task: Rain Forest Shelters

All the text could be coded and each strategy was identified as it appeared. The codes are shown in bold type.

Code: Focusing on the task.
R: So it has to go round all the time. If you see it's not going round then let me know.
(tape) OK, right, so I wonder what we're going to do today. Anybody know?
C: Making houses.
R: How do you know that, how do you know that?
C: 'cos the houses are over there and I watched last week.
C: Yes.
R: Did you? What kind of houses? What kind of houses are we going to make?
C: Tree houses?
R: Mm, could be.
C: Play houses?
C: Normal houses.
R: I know you know a lot about rain forests. If you were in a rain forest, what kind of shelter would you need? Who can tell me?
C: A waterproof shelter.
R: A waterproof shelter, why would you need that?
C: 'cos it rains a lot in the rain forest.
R: Yes, well done, because it rains a lot. Who else can tell what other kind of shelter you would need? Zoe?
C: Um. Camouflage.
R: A camouflage shelter, why would you need that?
C: So that no animals can come in.
R: yes.
C: It can be a green colour.
R: It could be a green colour.
C: Green for hiding.
R: Yes.
C: It has to be shady, it has to be shady 'cos it's quite hot in the the rain forest.
R: Right, it's quite hot so it needs to be shady in the shelter. Dominic?
C: Um, you need it waterproof or the rain would get through it.
R: Yes, we've said that, anything else? That we haven't said.
C: Um.
R: What else would we use? In the rain forest?
C: Weapons.
R: Weapons, why would you need weapons?
C: Animal skins for rugs.
R: Yes, there's weapons and animal skins for rugs, why would you need weapons?
C: To protect us.
R: To protect you, that's right.
C: Food.
R: Food, you would need food,Where would you get food?
C: Hammocks.
R: And a hammock.

C: Some animals.
R: Some animals, that's good. Someone said a hammock and I think that's a good idea too.
C: Yes, when they're in peg down.
R: Sorry?
C: Peg the tent down.
R: Have to peg the tent down, if you have a tent. Yes you could have a tent, or you could have um.
C: A green tent.
R: Mm?
C: A green tent.
R: A green tent would be a good idea.
C: That's what I said.
R: That's right.

Negotiation
C: Will you be allowed to work in partners?
R: If you would like to work in partners you're allowed to. (Some shake their heads) You don't want to and you don't want to. Well, you think about that, think about that. So what, what shall we do first?
C: Um, build the bottom of the house.
C: You have to start with the bottom of the camp or the shelter.
R: Right. OK.
C: The shelter.
C: Oh you've taken my base.
C: No this is mine.
R: Right, who wants a bottom, you've chosen a bottom already.
C: I'm with Zoe.
C: And I'm with Trina.
R: Right.
C: And I'm with you.
C: No I'm not.
C: I'm with myself.

Identifying wants and needs
R: What kind of bottom or base do you need, do you think?
C: I'm going to have a big bottom, bottom like that.
R: Right, you want that bottom? Right.
C: Have you got a rubber to rub this bit out.
R: Ah, there's something there you don't want? You want to rub it out? Right?
C: Yeah I'll do some, I'll do this side and you do the other side.
R: There. Why are you laughing? Why are you laughing?
C: It's big.
R: It's a big rubber yes.
C: It's a bit like a soap.
R: It's so big, that rubber, yes.
C: That is huge.
C: I saw one about that big.(indicates length with hands)
R: So what will you do first.

Focusing on task, tools and materials
C: Well I've got to do this. Mine's going to be a tent shelter.
R: Right, so what are you doing Dominic?
C: Making a tent shelter. Right. Folding the paper to make a tent shelter. That's an idea.
C: I'm making a tent shelter.
C: Really strong you know. (rubbing out marks on card base)

R: Got to be very strong for that rubber have you?
C: Yes.
C: I've got one there.
C: Nobody else is stopping me.
R: Nobody will be able to bother you.
C: Rub, rub, rubber. Rub, rub, rubber.
C: I'm not copying you, I'm just watching. (child watches the way card is folded by another to make a tent)
C: Rub, rub, rubber.
C: You're not copying.
C: That's a good one Paul.
C: What is it?
C: It's a door.
C: I need, um.
C: Which colour, green?
C: It's a door
C: Tents don't have doors.
C: We haven't done this door yet.
C: It's going to be like that.
C: How do they get out?
C: They come out, they open this flap and they come out.
C: I know.
C: I don't know what I'm going to do.
R: You're thinking are you?
C: Mm.
R: I can see her thinking hard.

Identifying wants and needs
C: Who's got...?, oh there's some glue. I'll get you the glue.
C: I don't know where the paper is.
C: Don't look over that Natasha.
C: I, I need some card.
C: Do it the other way 'cos it rubs out better.
R: What would you like?
C: I don't know.
R: well, look around.
C: Look around for a toilet roll if you want one.
C: One there. There's another one.
C: It's all right. So what are we going to start off with?
C: Need um.....(looking at resources).
C: I need to be on this side, this side is cleaner.
C: I need the glue.
C: Oh, Natasha you don't listen, I said it was here.
C: Dust it off. (brushes table)
C: Wipe it over.

Pretend play
C: I'm just going to have a little sponge. (uses rubber to clean table- pretend play)
R: Who's using my rubber like a sponge? (pretend angry)

Slight send up of teacher by children
C: That's sensible, Dominic. That's sensible. Dominic's being sensible, he's folded that so he doesn't have to do it very thin.
R: My goodness, that is sensible Dominic, you've folded back the bottom, haven't you? Just to make the tent like that. You've folded the bottom back and stuck it on.
C: Oh camera time, Dominic!

R: It is camera time. Because he's done a good job. (Dominic poses for a photo'.)
C: Right,

Identifying needs
C: We need some sticks. To stand up.
C: That bit can be the roof.
C: No, you need a little bit more.
C: No 'cos he's not going to have all of it.
C: 'cos I'm, I know but I'm really good at folding, aren't I?
C: I am quite good.

Conflict
C: Oi!
C: It's my wood!
C: It's not your wood!
C: Well, nearly.

Planning
C: Hold the top.
C: I'll do some gluing.
C: I'm going to be different to them.
C: I don't want to do one of these bits 'cos I want something with cloth over the top.
C: You want to do a big one then.
C: So that can be going on here and then that can be.....
C: I don't know.
C: What about the rain?
C: And animals. Dangerous.
C: What are you doing?
C: Make a door there.

Identifying difficulty and finding solution
R: Ah, it won't stand up. Is that what you're saying?
C: I need the pencil.
R: How could you make it stand up? Do you know?
C: I know, I know how you could. You could get a piece of paper and cut it in a circle a bit bigger than that. And stick that on there. And then you could, and then she could put some glue on the other one and that would help.
R: Ah, so that's how she could make the toilet roll stand up?
C: Yes.
R: Put a piece of paper round it?
C: It can stand up.
R: Oh it can anyway, she says. How are you making it stand up, then?
C: Oh I'm cutting the bottom in little snips.
C: I know but you could do the other side.
C: Make sure that side doesn't fall.
C: Know what, I need this to be brown.
R: You need that to be brown.
C: Colour it in brown.
C: Oh, where's the pencil then.
C: Will this glue come out?
C: You might have to just wipe that all off and then you can scrape that.
C: Mind but we need quite a lot and then it won't dry up so quickly.
C: No, I know, but then it's going spoil the edge.

Peer Evaluation
C: See that house, the tree house there with the ramp. I wouldn't want to live in there if I

had to the rain would make it hard to get in, 'cos I'd rather have a door.
R: I agree, you find it hard to get up that slope.
C: Yeah, if I had a wheelchair. It would be useful if you couldn't walk.
C: Right, right.

Planning
C: I know, we could make that bit stand up.
C: No.
C: Where are we going to have our beds?
C: Four beds?
C: I know, this could be the back of the house, that could be the bedroom and then that could be the shelter there OK?
C: I thought.....
C: So can I just do this quickly?
C: Yes.
C: The gluing.
C: On my own.
C: I think I need.....
Teacher: Are you wanting felt tips?
C: Yes.
C: Can we have the felts?
C: I need some boards like this.
R: Sorry.
C: I need some boards.
R: Well use them. It's OK. There's lots of boards, lots of bits here.
C: This is good fun!

Planning
C: What happens if we don't finish it today/
R: Well I think we've got to try hard to finish it today actually. Can you do that?
C: Yes.
R: Can you work really hard?
C: Now I put this on here.
C: Take a bit of that then.
C: Yes.

Tackling obstacles/Sharing and cooperating
C: Softest cheese, pretend it's cheese. And do it as soft as you like.(sawing)
R: What are you telling her to do?
C: Try and, um, pretend it's cheese and .....
R: How do you know to pretend it's cheese? **peer scaffolding transfer of skills**
C: 'cos you told me last time and I.
R: Oh that was a while ago. And that's quite right because that's what I always say. I say pretend it's cheese. How clever of you to remember .
C: That's it. That should be OK.
C: I know.
C: Push that there a bit.
C: There.
R: You've done it, well done.
C: Now I need a pencil on that bit.
R: You want a pencil, fine.
C: Right, that's one thing done. I'm just pushing it down, OK?
C: Yeah. Can you turn it round a bit.
C: Yes. Push.
C: Have you got any, like, circle sticks. Circle sticks?
R: Circle sticks?

C: Yeah the one's that go round. Um.
R: Cylinders? Yes.
C: Got that.
R: Ah down. Down, yes. The circle sticks are there.
C: Yeah.
R: Look deeper into the box....down.
C: Thank you.
C: But they're not very heavy Trina. They can't hold things, these can hold things, they can't. (comparing card rolls and wood sticks)
C: OK then. Cylinder, I'll put it there if anyone else wants it.
C: All right.
C: Can I do the side.?
C: I'm going to cut it.
C: Oh! I'll cut two bits and you can cut two bits 'cos we need four bits. And I've got the .....
C: Where's the glue?
C: We need that over there.
C: Why don't we take it over?
C: Right, can I just do this bit.
C: No, don't.
C: I need to use it.
C: Right, do it here. I'll put a line to mark the place. Right hold it there. A bit lower.
C: I need to cut it even.
C: No pretend it's cheese and do it softly. Then it..... **repeat scaffold**
C: Oh, I'm trying to do this, you're making it skid all over the place.
C: Hold the paper next. Or something.
C: It's going to work.
C: Don't.
C: I wouldn't part cheese like that I don't think.
R: Yeah?
C: Yeah.

Identifying difficulty/Tackling obstacles
R: Oh dear. Oh never mind, so what will you do? (door comes apart)
C: I'm going to do it on the other side.
R: Now you're going to put the door on the other side, I see.
C: Don't take long .
C: Never mind. That was funny wasn't it?
C: Wasn't.
C: It does take long time.
C: I can see the door from here.
C: There.
C: This is boring isn't it Trina?
C: No.
C: Sawing through wood?
C: Yes.
C: Takes a long time.
C: I'll do it.
C: That's done.
C: Yeah and now we need to mark. (wood so that the sides are the same length)
C: Can I do this bit?
C: I always leave a mark in.
C: Right, where's that ?
C: Oh can I just do two of the markings?
C: No, you're doing my markings.
C: OK, you can do two of my markings.

C: Pencil.
C: So, wait, wait. So this must be the middle then. **Transfer maths knowledge**
C: No.
C: We need another rod.
C: Yeah I think we will.
C: Right so this is like that.(nearly the same length)
C: And remember, Trina, I've just cut one . **Conservation**
C: I'll do that and then, so we make.....
C: I didn't have to waste any wood.(use a new piece of wood)
C: We could use that.(a piece that has already been cut)
C: We could at least make one out of that.
C: No we can't. They're not long enough look. (measures against a length they have cut)
C: That's too short.
C: We could get a couple of lengths and add that and this and put in there.
C: Should we put this through here or should we .....
C: I think we should stick it in the box in the box.
C: Yeah.
C: We'll have to glue it.
C: One.

Identifying difficulty / Tackling obstacles
C: How we going to take it through?
C: Spear the box.
C: Have you got a hole punch?
R: Have I got a hole punch? No I haven't, what, what would you like?
C: We need to make a hole punch.
R: A hole in there? Mm.
C: We glue it.
C: I think if we had a hole punched there. **identify need for new tool**
C: I suppose we might be able to get a, a spare one but...
C: Yeah you can.
C: Trace!
C: Sorry.
C: I'm going to have a look here. See what we can find for the house. Is that OK?
R: It is.
C: Wander about.(looking at materials) **researching materials**
C: I'm going to wander.

New focus to task
C: Think, try to get something to make the bed with.
C: You have to have a bed.
C: Make two beds, one for you and one for me.
C: Can I have some glue please, Dommy, Dommy. Dommy?
C: Yes?
C: Can I have some glue?
C: Have what?
C: Glue.
C: Glue?
C: I'm poking about, I'm being very very nosy.
C: Where's the felt tips gone?
C: Dominic.

Planning (time out exploring the materials)
C: Very, very. nosy.... then we could make four little legs out of this for the bed. Er, we have to make eight 'cos we're making two beds.
C: OK.

C: Do we need any um.
C: Well we might do, we might need a little bit of that. You can cut it. Yeah, cut it a bit 'cos.
C: Ah now.
C: You can, you can have that net on the top against insects.
C: Loads, loads.
C: Not in tents.
C: Yeah, tents roofs. Here.
C: No, that's the problem.
C: No.
C: Do you need any cotton?
C: Um.
C: Different colours there.
C: Er we could do. Yeah. Need er.
C: I need some of the cotton.
C: OK, what colour?
C: Green.
C: Yeah, OK I'll get you some brown.
C: There's the brown there.
C: That's blue.
C: Some for his one.
C: Take it off. Oh!
C: I'll get you a needle.
C: That one.
C: A needle to put .....
C: Yes you are allowed. (**checking what allowed in school**)
C: Can I, can I get the cotton for you?
C: You get up there a bit and then...
R: Well done, you've tried that lid for the, for the roof.

Planning

C: Right, don't need .....
C: Here's one.
C: I need that I think. Think.
C: Is that a whole house.
C: Oh dear.
C: It's this one, this one we need.
C: Oh yes. Where's the scribbler.
C: And we can use this as a bedspread, can't we. And we need um.
C: We need two more.
C: I was going to do that one.
C: And I'm doing the marking.
R: Ah, what you doing there Jason? With the cotton?
C: I'm going to put the cotton in the hole that I made and pull it around the top, that makes it look camouflaged .
R: What a good idea. What a good idea. So you're using that box?

Personal commentary on task

C: People would steal that in the jungle.
C: It feels a bit like Italian Cheese (parmazan) **extending scaffolding metaphor as discussing sawdust-very clever!**
C: Ugh!
C: That sprinkles on.
R: Ah! What is it you've got that feels like Italian cheese? What is it?
C: Sawdust.
R: Sawdust, I see.

Pretend Panic
C: And then we've got.
C: I'll just that stick. Quickly.
C: You've got glue on there. You've got glue on there.
R: Where have I got glue?
C: On there.
C: On your ring, on your ring.
R: Have I? Ah, I'll rub it off. Thank you.
C: Move the bits off.
C: Do it right up to this thing and then it might be a bit, oh no you can't, sorry.
C: Is this scrap, this?
R: Yes. That is scrap.
C: I might rip a bit off and use it.
R: Right, yes you can. .
C: What are you doing?
C: Oh dear, it's all going up.
C: One more.
C: That'll, oh yes.

Peer Negotiation
C: I need the floor.
C: This.
C: If anybody wants to use that.
C: Are you using that?
C: Oh yes, sorry.
C: Oh, can I just do one?
C: Scissors. Oh yeah, there they are.
C: Where's the brown.
C: Scissors.
C: You squiggle on that.

Sharing and cooperating
C: What you're doing?
C: No, but you're not going to be able to get quite three, you can get three out of that. With luck, one, two, (measuring fabric by eye). **transfer of everyday maths**
C: Oh but now Zoe, you know now we're using the pink material.
C: It doesn't matter.
C: .. then it will be quite good. Shall I do some camouflage things for this.
C: Um, no.
C: If I do a bit of orange. Or brown.
C: Um.
C: I'm going to cut this.
C: Zoe? For our shelter we can use this sanding type sellotape. ... and you keep a bit.
C: Yes.
C: Have you got any more of that colour?
R: Which colour is that? The, the brown.
C: Beige colour.
R: Beige is the colour. Yes, there's all of that there.
C: OK.

Planning
C: Zoe? You know the water hole here. You know the water in it, shall I cover this bit as animals might come through the hole?
C: That's good!
C: Not good.

Sharing work and cooperating
C: Right, can I start making a bed? Bedding?
C: OK, make them a bit smaller, OK?
C: I am. I know how small they are.
C: I'm making a tiny bed.
C: I need a bed.
C: Yeah, we're making two beds.
C: I'm not making a bed.
C: I'm just making a sleeping cover.
C: I'm making a wooden bed.
C: All right, um, Zoe, I'll start colouring this OK?
C: Yeah. Brown and a.
C: Orange, brown, green.
C: Yes.

Personal aside
C: It's all green the New Forest isn't it?
C: Yeah I went there.
C: My mum said.
C: Trina went there.
C: I know, I'm going there for my holidays.
C: And the wild wolf came up and they're quite tame even though they're wild and there's baby donkeys and there's mother donkeys.
C: And do they always have donkey 'cos um, they've got a little farm and.....
C: These are actually wild ones.
C: Oh.

Back on task -
C: Uh, what do I need now, yeah, pens, pens. Where have they gone? Where's the pe n set gone?
C: Mrs Roden?
R: Mm?

Requesting advice help as they know their own limitations (skills awareness)
C: Can you do this?
R: What?
C: That. Cut it with the orange marking.
R: You want to cut, why, why where the orange mark is?
C: 'cos we're doing a bed, and we want the um the same one.
R: Ah.
C: So we're going to copy.
R: Ah, the same size each time you mean?
C: Yeah.
R: Right. So.
C: Same length.
R: Did you, did you mark it there then?
C: Yes.
R: Right.
C: Right in the middle?
Scaffold
R: Right. You try. Now, what you need to do is this and then before you know it you've cut through but don't try too hard. Now you have a go. It's like your friend says, cheese. Pretend that you don't really want to do it. That better?

Practice
C: I can't believe this, 'cos I'm left handed and I'm doing it with my right hand.
R: Oh but why are you doing it with your right hand?.
C: It's easier I think.
R: Is it? You think it's easier?
C: I'm doing fine
R: You can do it with your left hand on the other side of the bench if you want to. See

Discussion of cooperation. Awareness of own cooperative strategies.
C: Zoe and me are getting on quite well.
R: You are getting on quite well.
C: That's good.
C: I'm getting on quite well.
C: On your own.

Discussion of time
C: When's it going to be dinner time?
C: You've had it, dinner time.
C: One.
C: (sings) It surely can't be time, you and me and two.
C: It doesn't go like that.

Showing and evaluating
C: Mrs Williams do you like our um, paper trees?
Teacher: That's nice.
C: Yes, we're making two beds to go in there.
Teacher: Oh are you?
C: I'm making a bed.
C: We're making, that's right, then we're making a shelter here so we can sit under it to have our lunch.
C: The cardboard isn't waterproof.
C: What?
Modifying
C: After mine I'm going to waterproof it

.
Discussion of tape recorder
C: Wrong way round.
C: I think your thing's not working.(tape)
R: You think what?
C: Your thing's not .
R: (looks at recorder) Yes it is.
C: Yep.
R: Turning round. Thank you very much. Dominic

Discussing task again, planning
C: Have you got any material?
R: Yes.
C: I need some green material.
C: Don't worry, I've got some.
C: That ?
C: How can I get through this?

Personal aside
C: Mrs Roden? Have you ever seen a lion?
R: A what?

C: A lion.
C: Have you ever seen one?
C: We have.
C: We saw the um, in zoos.
R: Did you?
C: I went in there.
C: We went in to see them.
C: Yes.
C: Did you get eaten?
C: No!

Self scaffolding
C: My Dad taught me how to start sawing. Saw.
R: Did he?
C: 'cos he said you always put it right near the back and then you pull it back and then you go forwards.

Practice
R: Oh now she's doing it.
C: You keep changing hands.
C: I know. I like to.
C: I can't.
C: What?

Modifications
C: Why aren't you doing that thing any more Dominic, with the cottons?
C: Didn't work.
R: Didn't it work, Dominic, with the cottons? Sorry? You couldn't get the cotton through the holes? No.
C: No.
R: That's sad, it won't stand up you mean?
C: No.
R: Oh. What can you do?
C: That the squiggly one.
C: Yeah I know we don't really do that one.
C: Lots more here.
C: We can make one more out of this .
C: Yes.
C: That could be just a spare bed.
C: Zoe?
C: What?
C: I'm just cutting a little bit off to make the same as yours.
C: No, don't. Don't. Shall we make a pillow? There's a bed, shall we make a thing where you put tea on and then there'll be a table here? You know that has a clock.
C: I need some glue .
C: Who's got the glue?
C: Someone.
C: Someone is Dominic.

Researcher led evaluation
R: How are you getting on Tracy, you're very quiet.
C: Who, me?
C: Yeah.
R: You're trying to put that paper over like that. OK. Did they?
C: That's good.
C: We're doing it but not the same colour.

C: We're not doing the table we're doing the bed.
C: The bed? That's not a bed.
C: It's going to be a double bed. With a sleeping bag at the top.
C: Yeah.
C: With a sleeping bag on it.
C: I'm not having a bed, I'm just having a sleeping bag.
C: We're having a bed with fur on.
C: I'm having a double bed.
C: Yes.

Comment on recording
C: Hello.(child passes from another group)
C: I'm doing my work.
C: Who did you say that to?
C: Camera. I mean um, tape.
C: Yeah.
C: You silly .

Discussing task again
C: I've cut it off already, look. Look.
C: I'm going to cut all mine off.
C: I've cut mine off.
C: Look, I've cut all mine off.
C: Look, I've cut all mine off.
C: I've only got this left.
C: I've got a .....
R: Oh my goodness, this is interesting.
C: There's a bed.
R: Oh that is interesting. How you doing?
C: I've put them in the house.
C: Oh that's good.
C: Keep them safe.
C: Um, I'm going to.
C: Is this?
C: That's the bit and that goes in there and now I'm going to put one of these there. And then you could stick a cover on both of them across there.
R: Yes.
C: Dominic thought of ideas.

Teacher led evaluation
R: Is that what you're going to do Dom, is that what you're going to do, Jason?
C: Yes.
C: I've got a rug in there so he can sleep.
R: A rug in there so he can sleep, yes.
C: And then, and I'm going to open that trunk so he can put things in.
R: What things might he have in there?
C: Weapons?
R: Yes.
C: Camouflage suits.
R: Camouflage suits, that's a good idea. Mm.
C: Helmets.
R: Mm?
C: Helmets.
R: Helmets.
C: Boots. To go in the jungle with.
C: Yes.

R: Glue. You're getting it on you, Mummy won't be pleased. Can you run and put an apron on?
C: I need the scissors.
C: I've finished.
R: You've finished, wow.

Researcher led evaluation
C: Then how do the men get out?
R: Ah, what do you think, what do you think Dominic?
C: You can cut, cut that open.
R: What, that door?
C: Just the side of it.
R: Just the side of it, what do you think? Yes? He thinks it's OK. Thank you very much for that.
C: Oh look, I don't believe you lot.

Panic, request for carefulness and help
C: Oh mind my jacket.(paint and glue)
C: You've got them all in here.
C: Not all of them.
C: Nearly all. And be careful in there.
C: Help me!
C: Careful.. you should.....
R: You have to be careful if you're using that.
C: Oh come on!
C: No.

Tape
C: Oh, it's still going.
R: Yes it's still going round.(tape)

Modification
C: I want to take it off.
R: You want to take it off now. You've really, she's really had enough of that, Natasha, and you thought it wouldn't stand up but it's standing up so well.
C: I want to take it off.(dissatisfied with part of shelter)
R: You want to take it off. Take it off. If you want to take it off.
C: In a round circle by the bushes. And then stuck in.

Negotiation of play time
C: Do we have to go out to play?
R: Well do you want to go out to play?
C: No!
R: Well, if....
C: I want to go out.
R: You can go out then.
C: I don't want to.
C: I don't.
C: When can finish it off then Dominic?
R: Well, it's up to him.
C: Oh OK, I'm going to stay in.
R: No, you don't have to. You don't have to.
C: I've finished, I've finished it now, I just need that to dry and I've finished it.
R: OK then, off you go and out to play Dominic

Evaluation
C: I've finished.
C: Yeah, I've done .
C: I've finished.
C: I've got an opening door.
R: Oh you've got an opening door?
C: Oh that won't stick.

Modification/Evaluation
C: Can you um, do this again?
C: I've made shield and a sword.
C: Can I go now?
C: What are you doing?(children pass on their way to play)
C: Making a..... see all those over there?
C: Yes.
C: We're making some of them.
C: Oh.
C: Sort of like houses that we'd like to live in in the rain forest.
C: I've made a handle.
R: Oh you've made a handle. Ah.
C: Nearly done it.
R: What could, what could that be for?
C: I know, I know something. If you, if you put it on,...
There's a handle, put it out and put it in.
R: Yes.
C: And you stick that on there.
R: You're going to stick that on there. Right. Right, who.
C: What's your name?
R: My name's Mrs Roden. And your name is Katie.
C: Yes.
R: I can see that.(wearing a hat with her name on)
C: Oh no.
R: Right do you want to go out to play? No? Natasha? No. Girls?
C: No.
C: No.
R: Right.
C: This pen's running out.
C: Oh 'cos we're allowed.
R: Mm?
C: Right, Zoe.
C: About jungles and rain forests. You see those houses up there? They're like tree camps. So we're the next group to do it. And so we want to, we're making what we'd like to live in in the rain forest.
C: Hey Zoe! Look this is where the .....
C: Oh deary me. You're a silly little girl.
C: I was talking to them
C: I know.
R: What are you doing with all that wood in there?
C: Er, we're going to make some into beds and some .....
R: Oh so you're saving it all in there are you? **Conserving materials**
C: Yes.
R: Right.
C: Storage shelter.
R: For storage. I see.
C: We're making a tree house of what we'd like to live in.

C: That's going to be a shelter. And that's, we're going to make some beds for it and.....
C: What's that colour?
C: Pardon?
C: What's that colour?
C: Er, orange.
C: I like that colour.
C: And that's brown, that colour.
C: Can we go out to play now?
C: Go on, you have to.

Modification
C: Can you go away please, we've got to do it on our own.
C: How many have we got now?
C: I've got four legs.
C: We need eight for two beds.
C: I know.
C: Twelve for three.
C: We've got four at the moment. Three and four.
C: Got them. ... glue it on now.
C: Right where's the glue?
C: Ugh!
C: Going to use some crepe paper for the lamp shade.
R: Now, what's Natasha doing now?
C: Um, I'm going to make a table.
R: Ah, you're making a table. What happened to your shelves then? You took it down? Yes.
C: All four of them.
R: Oh.
C: Trina look.

Practice and planning
C: What's that? (Learning new skill-drilling)
R: What is it?
C: We need a hole all the way through that way.
C: Well, we could it put through that way and tie it through the middle.
R: Which way?
C: Here.
R: Oh right.
R: Do you want to hold the drill?
C: I knew how to do that?
C: Mark it.
R: Right, what you going to mark it with? What are you marking it with?
C: Pen.
R: Pen. Right, so it that where?
C: Yeah.
R: That's where the hole's got to be. Right. So when you get this..... You know what it is?
C: Um, no.
R: It's a drill. There you are, you do it.
C: Yeah 'cos we're doing saws .
C: You can do the two of them while I carry on doing this.
C: I'll hold it.
R: Don't press, don't press. Just turn.
C: Oh they're all the same now.
R: Gently. **Scaffold**
C: I can do that drilling.
R: Is that enough?

C: Yeah, I think so. Something like that.
C: Can I get some?
R: Mm. Mm.
C: It's fun working with this.
R: Is it? What makes it fun?
C: I don't know.
C: 'cos we get to stay in on playtime and I don't like going out at playtime.
R: Don't you?
C: No. 'cos I haven't been well.
R: Oh.
C: Mm! She's gone through a rough time.
C: Mrs Roden.Can you cut, can you cut this? A little bit. **Asking for adult help**
C: Do it again.
C: So will you do another one then 'cos then I need one.
R: A little rectangle, how big?
C: Same size as hers.
R: That big?
C: No, there's another one that's going ....
R: Ah so three of those bits.
C: Right.
C: Got to make it.
R: OK?
C: Just do the squares.
R: That's going to be the table cloth? Oh.
C: This is quite good.

Focus on tools
C: Is this what they used in the olden days?
R: What that drill? What, why do you say that? Because it's.....?
C: Yeah, 'cos it's, it's not electric.
R: It's not electric no. It's not an electric drill. **Out dated technology in school**
C: I wouldn't think they'd have even this drill.
C: That could have been.
C: It's metal.
C: Is it?
C: Yeah, it's metal.
C: Oh yeah.
C: And this is wood.
C: Everything's metal except the handle.
C: And that.
C: Oh dear.

Identifying difficulties/Tackling obstacles
C: Oh, oh, look what.....
C: I think that looks a bit bad.
C: Can you put this on?
R: He's made a hole. In the bench hook. He's drilled right though to the bench hook. Never mind.
C: Will it matter?
R: Well, can't do anything about it now. Can we?
C: No.
C: We could do some more of these trees.
C: Let's do three more of these.
C: Yeah, and I'll do the flowers.
C: And then you can do the grass and I'll do that in a minute.
R: What you, why have you drilled the holes?

C: We're doing floor and we're tiling it at the bottom, we're gluing it, papering it.
R: Oh.
C: So it works all over.
R: Oh.
R: Ah, and how's Jason getting along?
C: Can I have a pair of scissors?
R: Oh there's the gun. I see.
C: Can I have a pair of scissors?
C: I don't like doing the pole vault.

Focus on tool (clamp)
C: Oh no. Goes right through the table, doesn't it?
R: What?
C: No it doesn't. It doesn't.
R: The clamp, no. No the clamp, why do you think the clamp is there?
C: 'cos holds that, so it sticks.
R: Hold the bench hook still, yes.
C: Three more.
R: Will you? Do you need five? Or not?
C: Yes.
R: Mm.
C: Right.
C: These can be a lot.
C: They need sawing.
C: Long ones?
C: Yes.
C: Right.

Practice
R: Well you've got lots of pieces of wood here. Are you going to put them together at all? (boys side tracked by practising sawing wood)
C: Uh, four, to make for the shelter.
R: Right.
C: I'm supposed to live in a raft.
C: Look.
C: Where's yours?
C: You took it.
C: No.
C: Have you got any double sided sellotape? (Asks for new resource)
R: Um, I did have.
C: Oh no!
R: Have a look in there. See if it's there.
C: What, have a look?
R: Yes.
C: Look what I'm doing.
R: What are you doing?
C: Making the drawers.
C: He's having a bed.
R: Mm?
C: There, a wooden bed.
R: Sorry what is it you want?
C: Can you hold the er, wooden stick? **Asking for adult help**
R: Hold the wooden stick.
C: There.
R: There?
C: Yes so I can saw

R: Right.
C: And so it will be safe.
R: Hold it there?
C: Am I allowed ?
R: Yes you are allowed. Look at, look at Jason, what has he put there?

Adult evaluation
C: Welcome.
R: Welcome, he's put on his house, that's a lovely idea.
C: There.
C: It's good!
C: Um, we're not going to copy that. **Copying not right?**
C: 'cos it was your idea.
R: What are you going to put in your house? Paul? You can't think of anything to put in your house?
C: Can we do something inside?
C: I'll get the tent up now.
C: I'll get the tent up.
R: You're putting the tent up now? Right.
C: Stay here.
C: What?
C: That's the decoration.
R: Ah, you've got decoration on your tent? I see. And Jason, what have you got here? Tell me all about it.
C: Make it camouflage.
R: You wanted to make it camouflage. So you put the.....
C: String and paper on it.
R: The string and the paper on. The brown and the green.
C: Are you making tree houses?
C: Yes.
R: Mm.
C: I made that.
C: When they get the green they're going to make some little plants growing.
R: Oh plants growing too, that's lovely.
C: There's one done.(flower)
C: Yes.
C: Dominic, Dominic.
R: How are we getting on? Because.....
C: Seven here. I thought there was, there was one more.
C: That's a lot.
R: Oh I see. Are you making the plants? Like that, Jason. With felt tip?
C: Yes.
R: Right.
C: Now here's the fire.
C: I said we're going to burn it.I need red.
C: No, yellow.
C: Oh yes.
C: I need a big piece of that don't I? Quite a long piece. 'cos we're making a double bed.
R: Ah right.
C: It's going to be cozy.
C: I've got sticky hands, I can't touch anything.
C: Wash them!
C: Where's the scissors?
C: You haven't stuck them.
R: Your hands are stuck to, your fingers are stuck to each other? Right how are we getting on here?

C: I don't know what to do next.
C: I do.
C: That's done. (cot)

Peer evaluation
C:What's that for?
C: A baby.
C: Oh.
C: I need .....
C: No it isn't. It's for you.
C: Oh it's too long.
C: No it's not.
C: Soft sleeping bag.
C: Can I have the um, glue.
C: You made a table.
C: Hey there' s that thing.
C: Please may I have the glue?
C: Canopy.
C: Why are you doing a canopy?
R: Oh dear.
C: Oh dear.
C: It's broke, it's split in two.
C: I've got, I've got a sleeping bag inside mine.
C: It's split in two.
R: Oh dear, it's split in two.
C: Snap, snap, snap.(bed broken)
R: Now, well.

Peer evaluation
C: Wayne's got a really good idea.
C: Oh no.
C: Trampoline.
C: Yeah, let's make a trampoline.
C: For to go up..... we can bounce up to the tree house.
C: That's a nice pen.

Tackling obstacle
R: Right, what are you going to do about it then?(broken bed)
C: We, we're, we're going to put the sellotape there and make it stick to a chair so we can another make a bed.
C: Nice sleeping bag.
C: So it can be two separate bits so it will be two chairs .
R: Oh I see, I see.
C: I'm putting a sleeping bag inside mine.
R: So it doesn't matter that it's broken now.
C: I'm putting my sleeping bag inside mine.
R: Ah, you're putting your sleeping bag in, inside yours? Oh I see, all rolled up. That's clever.
C: Are you going to put .....

Adult evaluation
R: Oh, now Jason, this is looking very good, what have we got here?
C: A parrot.
R: Sorry?
C: That's a log and a parrot sitting on it.
R: A log with a parrot sitting on it and.....?

C: A bird house.
R: A bird house. In the forest, I think that's a lovely idea.
C: There's two parts in the bedroom there.
R: Let me look and see who's in the bedroom. Is there anyone in the bedroom?
C: No not yet.
R: Not yet. And what are you doing now with the felt tip.
C: A lake.
R: Ah, so you've got a lake?
C: Can I have some blue paper.
R: Yes you can have some of that.
C: Where's the scissors?
C: I don't .....
C:There's my sleeping bag. I want to turn my sleeping bag in.
R: Mm?
C: I want to turn my sleeping bag.
R: You want to?
C: I want to have my sleeping bag a different colour.
R: You want your sleeping bag a different colour, right.
C: Where's the felt tip pen gone?
C: Going to colour ours the same colour.
R: What do you want?
C: Hold it straight.
C: Oh yes.
C: Hold it straight.
C: Hang on, hang on.
C: Right, now.

Peer evaluation
R: Where's Dominic, what happened to Dominic?
C: He's finished I think.
C: Don't look like it!
C: He just put it there!
C: Over there.Silly boy!
C: He's reading.
C: He's coming now.
C: Dominic!
C: I'll go and get him.
C: And that goes over us.
C: Where's the sellotape?
C: His only word was 'wait'.
C: Yes, he's coming now.
C: Come on.
C: Dominic, you haven't finished.(girls very angry with him)
C: I have finished.
C: It don't look like it! (teacher-like)
C: Why don't it look like it? (Dominic)
C: 'cos it doesn't.
C: What's wrong with it?
C: Furniture.....none! (pointing hard)
C: Yeah, there.
C: Where, here? (Dom points to outside his tent))
C: Yeah.
C: You can't do it there, everything else is inside the tent.
C: The shelf isn't.(Dom)
C: Well can't you make something like Jason's? Look. Come over here. Look, I'll show you what he's done at the front.(girls drag Dom to look at other boy's work)

C: It says welcome, couldn't you do anything like that?
C: You think I ought to mark the door?
C: We've got double sided sellotape now.
C: Um.
C: .... there isn't anything you can do Dominic!.
C: Anything!.....(girls move off shaking their heads and rolling their eyes)
C: What's in there?
C: I need something to .....
C: I'm going to .....
R: What are you going to do?
C: A little star.
R: Little stars. Ah.
C: Oh dear.
C: Look at this.
R: What is it?
C: Oh it's just a little wobbly. (the chair she has made)
R: A little ....., oh.

Focus on materials
C: Don't knock that over, OK?(the tube of sequins)
C: I won't.
R: Why mustn't she knock it over?
C: 'cos it might go over the floor.
R: Oh, what's inside them?
C: Er, the little stars.
C: What little stones?
C: Stars.
C: Ooh.
C: What do they do?
C: They eat you Dominic.
C: What, pop stars?
C: Pop stars!
C: What's that?
C: What is it?
C: Pebbles.(looking at sequins)
C: Sparkly stars, aren't they?
C: Hey, stop it!
C: Not going to use too much.
R: Why not too much.
C: 'cos you might use them all up. **Conserving**
R: Ah right, why don't you want to use them all up?
C: Well because you'll have to buy some more.
R: I will, yes. Have you finished your shelter Natasha?
C: No, I've tried to do that other things like the bed and table and tablecloth....see..

Modification (in response to peer evaluation)
C: I've done it.
R: Dominic?
C: Done it.
R: What have you done Dominic?
C: I've put, two, two, um, things...bars... there so animals can't get in.
C: Best to get that in so you can be safe.
C: I've done it.
C: Can I have some of that, some of that fur?.
R: Right it's finished now is it.
C: Little things left to do.

R: What's inside?
C: Um.
C: Trina! She won't let me have any of the little ones.(glitter)
C: We've got it. Here.
C: The little ones.
C: What?
R: What the tiny pieces of glitter?
C: The glitter, put your hand out.(child carefully dispenses the glitter)
C: The glitter.(friend carefully carries glitter to her model)
C: I need the glitter too.

Adult led evaluation
C: Oh Mrs Roden. I've finished now.
R: Right so we've got another finished shelter, look at that. Oh wow! All sorts of things, now that's new. I haven't seen that Jason. What does that do?
C: It's a kennel for the dog.
R: It's a kennel for the dog. Well, so you've got a pet dog in the rain forest.
C: Yes.
C: That looks like a real one.
C: What?
R: Well, what, and how about that bit there?
C: That....That's where they're cooking.
C: Do you want to do it? You can cut some with us.
R: Goodness me, there's everything in this house.
C: Let's pour these back in. (sequins in the tube)
R: Come and tell me all about it. Come here. What have we got? You've got.....
C: That's an axe.
R: That's an axe.
C: That's for knocking down doors.
R: That's for knocking down doors, yes.
C: That's his jumper.
R: That's a jumper.
C: That's his gun.
R: And that's a gun. So all of those things he's going to need isn't he?
C: And that's him.
R: Oh there he is, there he is, I see. You've drawn him there. Right. And that's the handle to open the door, mm.
C: Yes.
R: And that's the.....
C: Pieces of bush to make a camouflage.
R: Right, that's the, the pieces to make a camouflage. And there's a.....
C: Bird house.
R: Bird house. And a...?
C: Dog kennel.
R: And?
C: For letters.....
R: A letter box, yes. And a...?
C: You'll have to do a bit of glitter on the other side now, Zoe.
C: Look, look.
C: Lake.
R: The lake. And the....?
C: Zoe, Zoe, look.
C: Doorway.
R: And the doorway. And the...?
C: The mat.
R: The mat that says welcome on. My goodness. Oh and something on the front door.

What does it say there?
C: Keep out.
R: Keep out on the front door. My goodness. I'd quite like to move into your house Jason. Would you like to move in? Yes? So, anything else? Or is it finished?
C: It's finished.
R: It's finished, right. And where are you going to put it? Up there?
R: We've got Natasha, and what's Natasha got?(She presents her model)
C: A table with an umbrella.
R: A table with an umbrella, mm.
C: A present.
R: A present for somebody on the table.
C: And then I've got a tent.
R: A tent. So you made your tent last of all?
C: And that's a doormat.
R: And a doormat. Right, is it finished?
C: Um, no.
R: No? What more have you got to do?
C: I just need to glue that there and then .....
R: Ah, right.

Peer evaluation
C: Zoe, you haven't finished the shelter and that's important part.
R: What have we got here? This is Paul's and he's got a tent with a...? A tent with a...?
C: A green cotton door.
R: A door. And? What's inside the tent...?
C: I'm supposed to do this door.
C: So?
C: My sleeping bag.
R: The sleeping bag, right. Have you finished now then? Yes? Thank you. Where will you put it? There?
C: Um. Here.
C: Got to be getting on quickly now. (teacher-like)
C: At the bottom now.

Adult led evaluation
R: And how are we getting on here girls? You're the last ones.
C: Yes.
R: What. Tell me about yours?
C: Well, this is where the er, real where we are going to put two beds in there. That's rolled up to make some chairs.
R: Mm.
C: And um, just here we're making a shelter.
C: Hey Dom! Dominic. (squabble over wood)
C: And we're going to er, sometimes if it's not raining, we can sit under here, and sit under the shelter and eat our lunch.
R: Right. That's very good. What have you got on your shelter?
C: Um, there's some glittery stars and some cylinders, gold and red cylinders.
R: Ah.
C: And our camouflage bit.

Modifications
R: And now you're trying to keep that standing up, yes?(canopy)
C: Oh dear I haven't finished the bed, here, have I?
C: This wont' work. (supporting the canopy)
C: I need some tape.
C: I'm looking for the scissors.

C: I can't seem to fit that.
R: You can't seem to fit that on? (fabric on the poles)
C: Just leave it like it is.
R: And you want that to stand up there do you?
C: Yes.
C: I need that ..... Oh wait, I need to um, look.
R: It's hard to stand up. Yes, that's a good idea. Wrap the tape round.
C: Glue now.
C: Right.
C: Cover the table up.(putting table cloth on tiny table-play
C: Oh where's the glue thing. (spreader)
C: We can just do one. (plate)
C: Right, what are we doing then?
C: That's going to be one, just one for the middle of the table so we can have some food.
C: Right. So,now....(cuts tiny plate)
C: (sings) I'm using something. I'm using very very big. Very very big indeed.
C: Zoe.
C: I'm doing a totally different idea from hers.
C: Um, I just need to stick that on there.
C: And I just need to, stick, where's that, stick it.
C: Oh!
C: Have you got any double sided tape left?
R: No, I haven't got any left.
C: What's double sided double sided sellotape?
C: Double sided sellotape? It's got two sticky, on each side.
C: Where's the tape?
C: The tape? I don't know.
C: (sings to canopy) You are my sunshine, my only sunshine.You make me happy...
C: Oh this tape.
C: That can go underneath.
R: Right, come along.
C: Can you just get this to fit?
C: Actually, I need to.
C: No.
C: Where?
R: Now, what are you doing now, girls?
C: I just need to er, get a piece of glue and.....
C: Trina there's no just in this.
C: Oy! Trina!
C: It is a silly idea. (using sellotape)
C: What?
C: Like that.
R: All right, we need to clear up. We need to clear up because it's home time. Girls we need to clear up now.
C: Can you just hold this. (gives R wood to hold)
R: Everybody needs to clear up.
C: Zoe.! help quick.
R: Do you need .....?
C: Just one.
R: Right, come on, the chairs are going up.
C: Hey, thanks.
C: Trina!
C: You are my shading, my only shading.(sings to canopy)
C: Trina, what's your little brother called?
C: Don't you know?
C: Gregory.

C: Gregory.
C: He's not.
C: Gregory.
C: Gregory, your little brother is.
R: Packing up girls, come on.

Appendix 3
Using Systemic Networks

Introduction

Systemic networks were used in a pilot study at the beginning of the analysis. They were a first step in identifying and classifying young children's problem solving strategies. The networks were structured to make explicit a child determined cycle of strategies. They were useful because they served to both categorise and describe the children's strategies, and to distinguish their options or choice of action for D&T activities during the Reception year. The networks also displayed the relationship between these choices, children's own wants and needs, and the constraints of the context. They were valued as both an analytic coding and a knowledge representation device.

Networks were constructed half way through the Reception year and at the end of the year, for the same children, engaged in similar D&T tasks. As the same notation was used each time it was possible to compare and contrast the networks and trace the children's strategies as they evolved and changed. It is important to note that, unlike the taxonomy, the networks were derived from children's single utterances rather than blocks of group dialogue. But they were a first attempt to address questions concerning:

* Initial identification and classification of children's problem solving strategies.

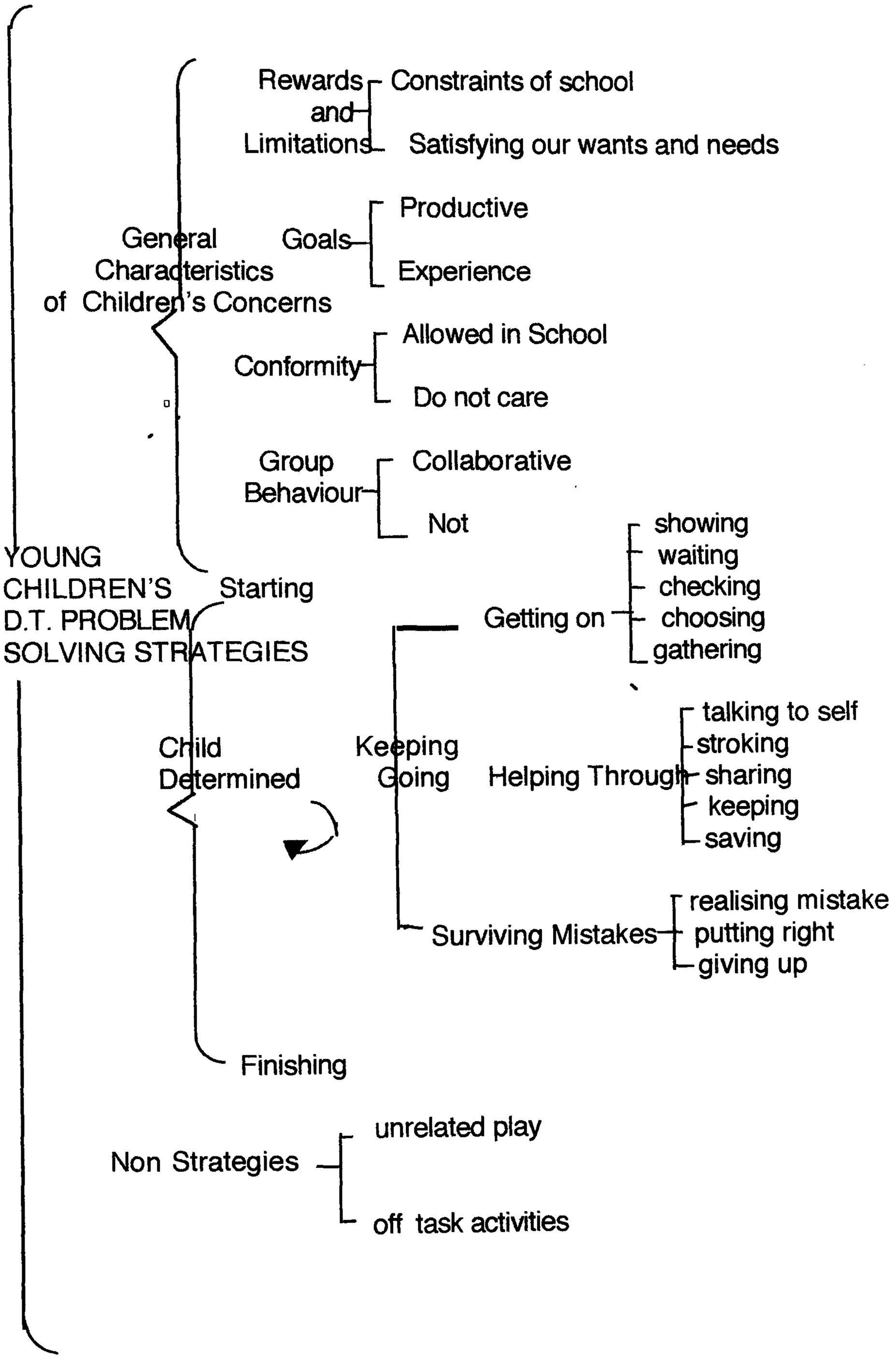
* Frequency and consistency of strategies during the first year at school.

* Change in strategies during this time.

At the beginning of the study the networks were used as an initial attempt to identify and classify strategies but also to represent them in a form which allows the task to be seen through the children's eyes. They were couched in children's terminology, and reflect their wants, needs and concerns as they tackle the D&T tasks. Initially, they were useful because they were a good way of reducing a large and complex amount of data, so that results may be seen and compared at a glance. Although they focused on individual utterances, it was then possible to use these results as analytical tools concentrating on larger blocks of dialogue and more group interaction, to begin to create a taxonomy. In this section the networks are presented and explained in chronological order, and then comparisons are made.

[Fig 1]

Systemic Network: first year of school.



1.1 The Systemic Network: First year in school

The network was constructed from tasks done in the first year of school. It was generated from the children's responses to the first and second D&T tasks at Gorden Park School. These tasks were done half way through the Reception year, when the children were making Greeting cards, and at the end of the year when they made Invitation cards for a Teddy Bears' Picnic. The same three groups of six children did each task. These children were grouped into the oldest, middle and youngest in the class. The network was used as a first attempt to identify, structure and present the children's cycle of strategies. It distinguishes between two areas: the children's specific strategies and general characteristics of these strategies, although these sub-networks are interdependent (FIG 1). A central Bar was constructed of mutually exclusive categories. These categories were couched in young children's phraseology and represented a selection of strategies designed by them to cope with the demands of the problem solving situation. The cycle of the session had a natural recurrence, hence the recursion notation, and aimed to focus not on starting and finishing, as more data is needed here, but on the way the children see themselves as maintaining the momentum of the session or in their own words (KEEPING GOING).

Pupils' choice of strategies were presented in terms of how they responded at the beginning of the technology session (GETTING ON), how they helped themselves or others (HELPING THROUGH), and how they encountered and responded to error (SURVIVING MISTAKES). The children's initial strategies, such as deciding upon materials and ideas (CHOOSING) and collecting resources (GATHERING), were devised to get themselves started on the task and were shown as mutually exclusive categories in the network. Strategies to aid their individual progression were evident, such as telling themselves what to do (TALKING TO SELF) or offering work to others for their opinion (SHOWING). Hoping for someone else to act (WAITING) was also apparent, and confirming their ideas with others (CHECKING).

Cooperative strategies played a large part, for example 'I'll get the glue on then you sprinkle the glitter over' (SHARING), and comforting rather than squabbling were surprisingly evident: 'You just had a little accident with the paint. Don't worry, that's it. There you go' (STROKING). Conservation strategies were also much in evidence, especially where materials such as sequins and tinsel were highly valued by the group, and it was possible to discern the progression of conservation techniques from the youngest to oldest group (SAVING). However, holding resources for their personal use was also perceived by the children as a useful strategy (KEEPING).

SURVIVING MISTAKES entailed strategies concerned with acknowledging error: 'I'm so silly, aren't I? All my hands have gone gold' (REALISING MISTAKES). Taking action to rectify error (PUTTING RIGHT), and discarding work completely was used by individuals or pairs (GIVING UP). Categories of behaviour perceived as possibly non-strategic in terms of tackling the task, such as unrelated play, off-task or other activities, were shown separately in the network.

The network attempted to create a means of describing young children's strategies in their own words. It was accessible to adults and simple in structure. However, this apparent simplicity may conceal the sophistication of the strategies themselves. The complexity of these procedures, apparently designed to achieve certain aims, was quite revealing. It prompted questions concerning the motivating force behind these activities for the children: what concerns urged them forward? These formed a GENERAL CHARACTERISTICS OF CONCERNS, co-selection or 'Bra' in the network. The bracket, abbreviated to 'Bra', is used in a network where options co-exist therefore, although children would use only a selection of strategies all would be subject to their basic concerns.

1.2 Consistency and Frequency of Responses: The First Task

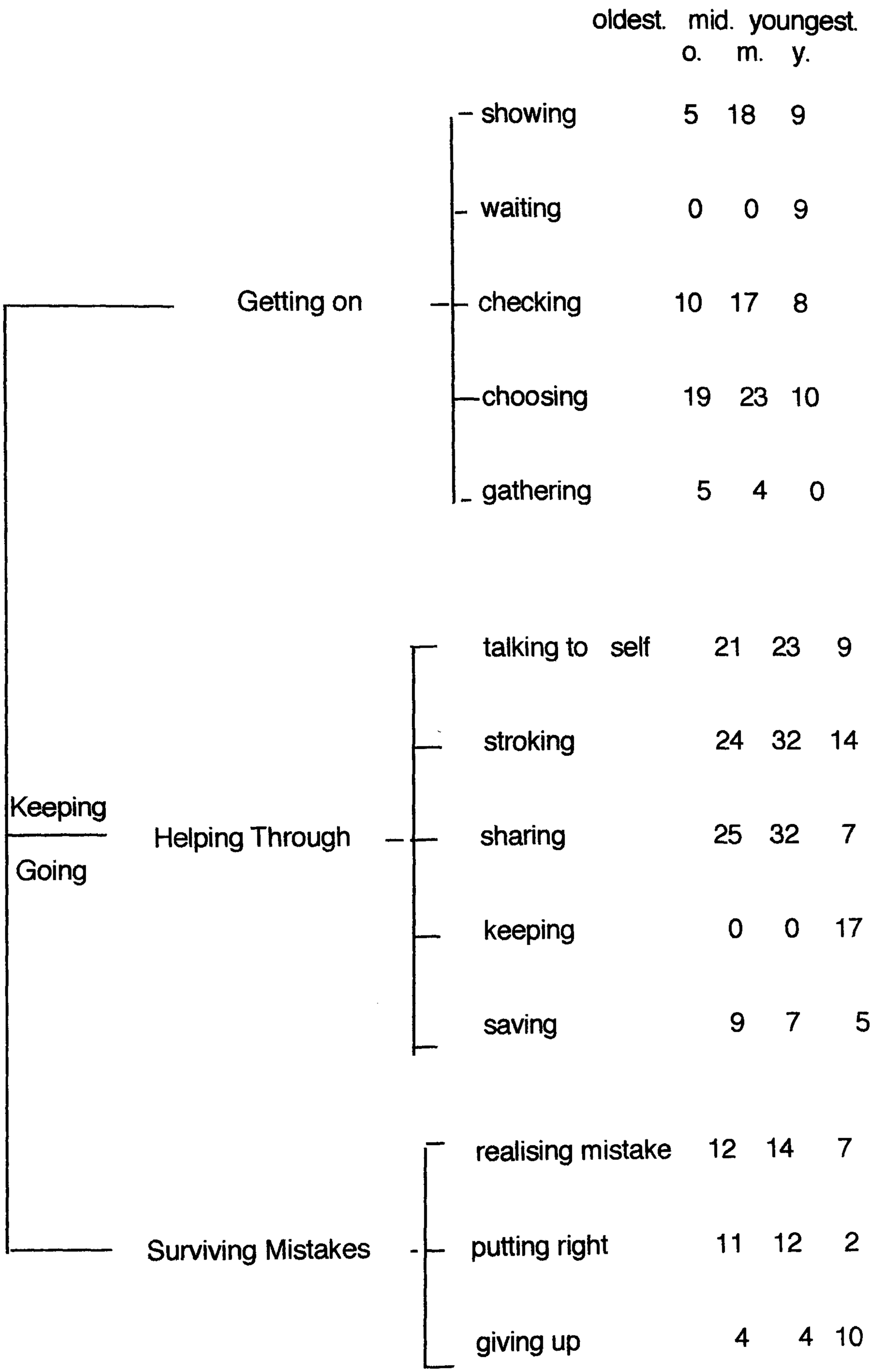
The number of responses in the network categories were noted for the first task when the three groups of children had been four months in school, and were making Greeting cards, in December (Fig 2). Noticeably the incidents of STROKING, SHARING and TALKING TO SELF had a high profile across all three groups. They were consistently high during the D&T task and seemed to mark the balance between the individual yet collaborative focus of the activity. CHOOSING also occurred relatively frequently for all groups, while REALISING MISTAKES and PUTTING RIGHT seemed to be consistent with young children's ability to see that they have made an error, although they do not always know what to do about it. WAITING, KEEPING and GIVING UP, all apparently 'passive' strategies, were most infrequent overall, except for the youngest group.

It was noticeable that the responses of the youngest group were less frequent than those of the middle and oldest, except for WAITING, KEEPING and GIVING UP. These seem to be the most 'passive' and 'egocentric' strategies. STROKING also gained a high response in the youngest group, perhaps reflecting a need for greater confidence in these youngest children.

Strangely, the most frequent responses in nearly all network categories occurred in the middle age group rather than the oldest. This is perhaps understandable in TALKING TO SELF and STROKING, but CHOOSING, CHECKING, SHOWING and SHARING were also highest for this middle group. There seemed to be a very strong proactive attitude to 'GETTING ON' with problem solving in this middle group, and also a strong collaborative stance for HELPING each other THROUGH the task.

In contrast the oldest group used SHARING and STROKING less frequently as a collaborative strategy. This decline in collaboration is matched by less SHOWING, but also talked themselves through the task less. However, their conservation strategies were slightly higher, SAVING materials for later use, and they were more proactive in GATHERING resources at the start of the lesson.

[Fig 2] The First Task: Number of Responses the Network Categories.



[Fig 3] The Second Task: Number of Responses in the Network Categories

			o.	m.	y.
Keeping Going	Getting on	– showing	13	5	9
		– waiting	0	0	0
		– checking	30	27	48
		– choosing	6	21	37
		– gathering	4	4	8
		* playing	9	17	21
		* helping teacher	19	0	0
	Helping Through	– talking to self	12	18	26
		– stroking	12	2	2
		– sharing	38	31	79
		– keeping	0	6	20
		– saving	15	2	7
		* copying	16	0	0
	Surviving Mistakes	– realising mistake	10	8	16
		– putting right	6	2	16
		– giving up	7	2	18
		* blaming	19	0	0

* emergent strategies

1.3 Consistency and Frequency of Responses: The Second Task

The number of responses in the network categories were noted for each group during the second task, making Invitation cards, in July at the end of the Reception year (Fig 3). Overall the most significant features were the high frequency of SHARING strategies, shown particularly by the youngest group, and also the frequency of CHECKING, KEEPING and TALKING TO SELF found again, particularly in the youngest children. The other most noticeable feature was the occurrence of newly emergent strategies of a kind not evident before. The oldest group of children exhibited more SHOWING strategies. They also demonstrated more frequent STROKING and SAVING strategies, continuing a tendency towards conservation. TALKING TO SELF continued to decline in the oldest group, but so did REALISING MISTAKES and PUTTING RIGHT. This may be due to children's increased awareness of lack of status and self-esteem in school, connected with getting things wrong.

Interestingly, new strategies emerged by the end of the Reception year. These were PLAYING, HELPING TEACHER, COPYING and BLAMING. Apart from PLAYING, these emergent strategies were used exclusively by the oldest group, and were remarkably frequent. PLAYING was used most frequently by the youngest group, and mainly to investigate materials and processes, but self structured play was also used by the middle age group. There was also some unrelated play and off-task activities.This middle group exhibited noticeably fewer strategies than either the oldest or youngest group, in all the categories except TALKING TO SELF, PLAYING, CHOOSING and CHECKING, but here these strategies seemed to be in decline as the children got older.

1.4 Comparing Children's Responses to the Two Tasks

The number of responses in the network categories were compared for the first and second tasks (Fig 4). Overall, it could be seen that all the groups exhibited very frequent SHARING strategies. In fact, the incidence of SHARING levelled in the middle group, increased in oldest group, but increased markedly in the youngest children. CHECKING also showed a marked increase in all groups over the period, but again the youngest group made the greatest strides.

The responses in many of the other categories seemed to follow a pattern. This showed the strategies of the youngest group becoming more frequent, but those of the middle group declining, and the oldest declining even more. This pattern occurred in CHOOSING, TALKING TO SELF, REALISING MISTAKES, PUTTING RIGHT, and to a lesser degree GATHERING and GIVING UP. Some strategies, such as WAITING and STROKING, seemed to occur less frequently in all groups as they grew older, whereas others such as SHOWING seemed to follow no definite pattern. But the conservation strategy of SAVING increased significantly in the oldest group. The newly emergent strategies of HELPING TEACHER, COPYING and BLAMING seemed to occur very frequently when they materialised in the oldest group during the second task at the end of their Reception year. In contrast, PLAYING emerged in all groups, but most frequently in the youngest.

[Fig 4] Comparison of Responses to the First and Second Tasks.

o. oldest pupils
m. middle ..
y.youngest ..

				o.	m.	y.
Keeping Going	Getting on	showing	1st	5	18	9
			2nd	13	5	9
		waiting		0	0	9
				0	0	0
		checking		10	17	8
				30	27	48
		choosing		19	23	10
				6	21	37
		gathering		5	4	0
				4	4	8
		* playing		9	17	21
		* helping teacher		19	0	0
	Helping Through	talking to	self	21	23	9
				12	18	26
		stroking		24	32	14
				12	2	2
		sharing		25	32	7
				38	31	79
		keeping		0	0	17
				0	6	20
		saving		9	7	5
				15	2	7
		* copying		16	0	0
	Surviving Mistakes	realising mistake		12	14	7
				10	8	16
		putting right		11	12	2
				6	2	16
		giving up		4	4	10
				7	2	18
		* blaming		19	0	0

* emerging strategies

1.5 Variation in Strategies during the First year of School.

During the last six months of the Reception year there seemed to be noticeable differences in the consistency and frequency of strategies used by pupils. This appeared to be characterised by how long the children had been at school. This time corresponded to the age of the children, but although the type and range of strategies used by all groups were similar, the number of times these were exhibited seemed to vary.

During the first task, half way through the Reception class, children from the oldest and middle age groups used more frequently strategies associated with 'assertiveness' such as SHOWING and CHOOSING. The youngest pupils used CHOOSING and GATHERING strategies only infrequently, but exhibited a more passive and possibly 'watching and learning attitude' by using more WAITING strategies. Throughout the first D&T task the middle and oldest groups were perceived to be the most decisive pupils.

However, there seemed to be a variation in responses as the children grew older. In the second task the youngest children increased the frequency of strategies in all the 'assertive' strategies, such as CHOOSING, GATHERING, CHECKING, REALISING MISTAKES and PUTTING RIGHT, and incidence of 'passive' WAITING declined.

Comparing the analysis of the first and second tasks it was apparent that many of the strategies exhibited by the children in the first task were still present in the second. The youngest groups were now using the same strategies as the oldest in the first study and were more pro-active or assertive, judging from the number of responses collected and classified. But the oldest and middle groups' strategies, except for CHECKING and SHARING, were consistently fewer in number. Over the six months from the first to the second task, the youngest children's problem solving strategies had appeared to develop rapidly. Comparatively, the middle group's strategies seemed to stabilise, and the oldest group seemed to exhibit appreciably fewer strategies.

An equally interesting aspect of the data was the identification of newly emergent strategies of a different nature to those found in the first task. As STROKING strategies seemed to decrease in number, so COPYING and BLAMING emerged as new strategies. As TALKING TO SELF appeared to decrease in the older groups, so HELPING TEACHER appeared. Alice declares 'Katy's gone. She isn't helping you tidy up. She crept outside like a little old tortoise'. After many accusations concerning one member of the group copying another, Orin whispered, 'See that tape recorder? It's copying everything you say. Don't say a word ! '

1.6 Charting Strategy Variation

The variation in children's strategies can be traced through the the networks (Fig 5). It can be seen that, over the second half of their first year in school, most of the youngest group's strategies were associated directly with pro-active problem solving and these were developing, whereas their passive behaviour was in decline. Conversely, the middle group's interest in the problems posed seems to have been declining, as does that of the oldest group, who seem more likely to give up. For the oldest group, social aspects of the task, such as sharing, conservation and showing, are important. This social awareness is also reflected in emergent strategies, such as copying, blaming and helping teacher.

(Fig 5) Variation in Children's Strategies during the first year of school.

Group	Emergent	Developing	Levelling	Declining
Youngest	Playing	Choosing Gathering Checking Talking to self Sharing Realising mistakes Putting Right	Showing Saving	Waiting Stroking
Middle	Playing	Checking Keeping	Choosing Waiting Gathering Sharing	Showing Talking to self Saving Realising Mistakes Putting Right Giving Up
Oldest	Playing Helping teacher Copying Blaming	Showing Checking Sharing Saving Giving up	Gathering	Choosing Talking to self Stroking Realising Mistakes Putting Right

A Basis for Further Analysis

The network identified and classified a number of problem solving strategies and this was a base from which further analysis could take place. There could then be an attempt to codify the transcripts with the initially identified strategies to form the beginning of a taxonomy. Many of the strategies identified by this pilot study, for example CHOOSING, GATHERING, REALISING MISTAKES and PUTTING RIGHT, seemed to be fundamental to learning in D&T. The network demonstrates how children use strategies to self regulate and evaluate their work, such as SHOWING and CHECKING, and also strategies that help them plan, such as CHOOSING and GATHERING. But it is debatable whether all the perceived strategy development outlined here is conducive to success. Emergent strategies such as imitating others (COPYING) are the basis of modelling in D&T, and this is essentially useful, but children seemed to view it as cheating and complained bitterly when it happened (BLAMING).

Collaborative strategies were also evident from this short pilot study. Working together (SHARING) was identified, as was assisting adults (HELPING TEACHER). Playing was used to investigate materials, communicate and relate learning to friends, and unrelated play also maintained good relationships. STROKING showed empathy, and conserving materials and tools for friends (SAVING) also demonstrated cooperation.

Insight into children's motivation, from the pilot study, helped us to understand the data during the second phase of analysis. The children's main goals seemed to be to produce an end product which related to their own interests, wants and needs, and hopefully to take it home, and to gain hands-on experience of the tools and materials used. There seemed to be a relationship between children's motivation, their learning strategies and the classroom culture. In seeking to comply with the constraints of the context the older children seemed to revise their strategies accordingly. They constantly checked their ideas against those of their peers and their teacher, and worked within what they perceived as 'allowed'. They focused on their own values of producing a product, using the resources and working with friends, regardless of the task as perceived by the adult.

From the initial pilot findings it seemed that during the D&T process children appear to start school with an initial set of available learning strategies. These may vary according to maturity but they seem to develop rapidly and be subject to change. Through the use of networks, it was possible to begin to identify and classify these strategies. This work, based on data gathered by working with children during their first year at school, had gone some way in identifying these children's problem solving strategies during two similar design and technology tasks. But this was merely a starting point for further in-depth analysis towards a taxonomy.